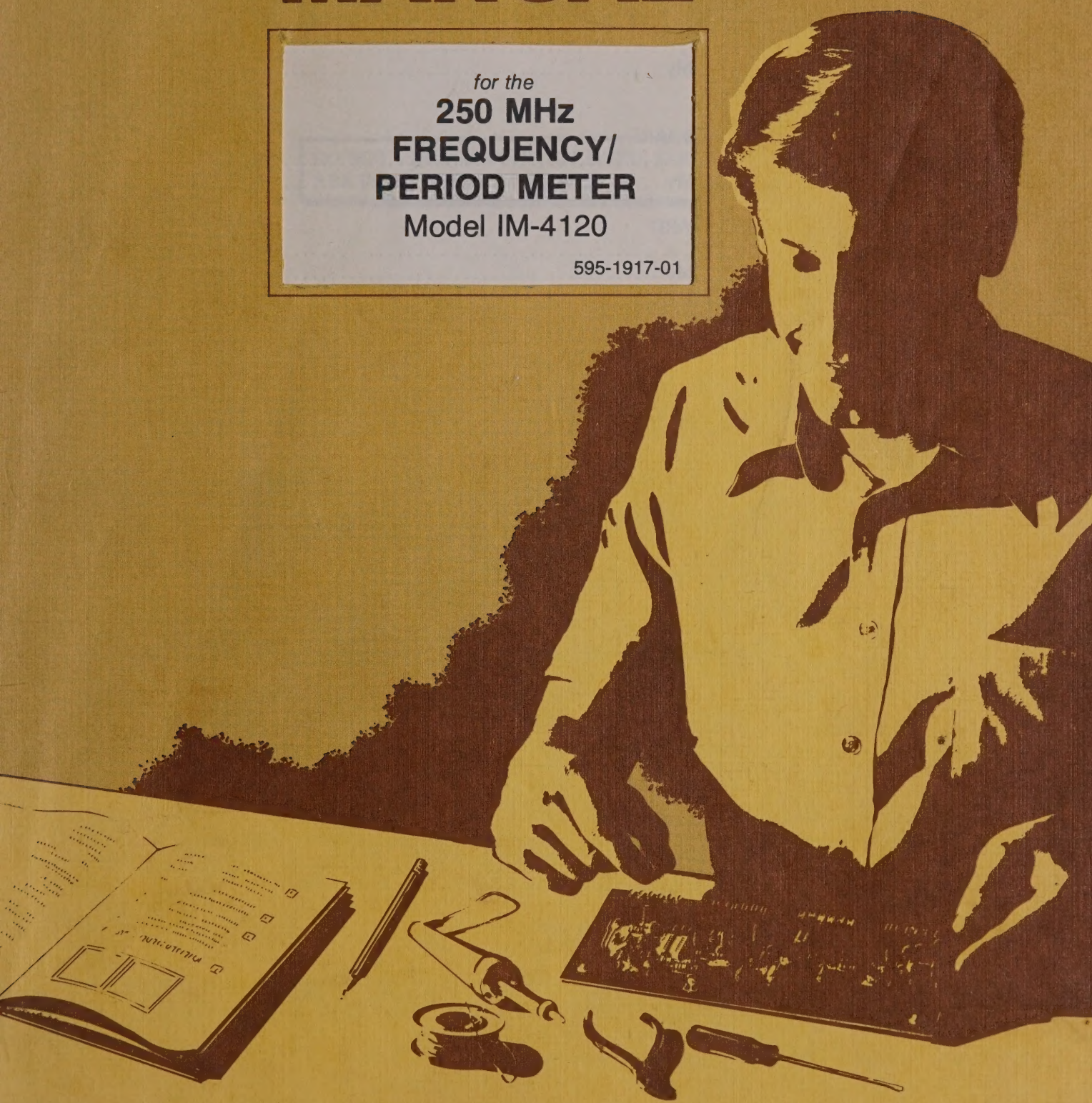
HEATHKIT® MANUAL

for the

250 MHz FREQUENCY/ PERIOD METER

Model IM-4120

595-1917-01



HEATH COMPANY • BENTON HARBOR, MICHIGAN

HEATH COMPANY PHONE DIRECTORY

The following telephone numbers are direct lines to the departments listed:

Kit orders and delivery information ..... (616) 982-3411
Credit ..... (616) 982-3561
Replacement Parts ..... (616) 982-3571

Technical Assistance Phone Numbers
8:00 A.M. to 12 P.M. and 1:00 P.M. to 4:30 P.M., EST, Weekdays Only

R/C, Audio, and Electronic Organs ..... (616) 982-3310
Amateur Radio ..... (616) 982-3296
Test Equipment, Weather Instruments and Home Clocks ..... (616) 982-3315
Television ..... (616) 982-3307
Aircraft, Marine, Security, Scanners, Automotive, Appliances and General Products ..... (616) 982-3496
Computers ..... (616) 982-3309

YOUR HEATHKIT 90-DAY FULL WARRANTY

If you are not satisfied with our service - warranty or otherwise - or with our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan 49022. He will make certain your problems receive immediate, personal attention.

Our attorney, who happens to be quite a kitbuilder himself, insists that we describe our warranty using all the necessary legal phrases in order to comply with the new warranty regulations. Fine. Here they are:

For a period of ninety (90) days after purchase, Heath Company will replace or repair free of charge any parts that are defective either in materials or workmanship. You can obtain parts directly from Heath Company by writing us at the address below or by telephoning us at (616) 982-3571. And we'll pay shipping charges to get those parts to you — anywhere in the world.

We warrant that during the first ninety (90) days after purchase, our products, when correctly assembled, calibrated, adjusted and used in accordance with our printed instructions, will meet published specifications.

If a defective part or error in design has caused your Heathkit product to malfunction during the warranty period through no fault of yours, we will service it free upon proof of purchase and delivery at your expense to the Heath factory, any Heathkit Electronic Center (units of Schlumberger Products Corporation), or any of our authorized overseas distributors.

You will receive free consultation on any problem you might encounter in the assembly or use of your Heathkit product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

Our warranty does not cover and we are not responsible for damage caused by the use of corrosive solder, defective tools, incorrect assembly, misuse, fire, or by unauthorized modifications to or uses of our products for purposes other than as advertised. Our warranty does not include reimbursement for customer assembly or set-up time.

This warranty covers only Heathkit products and is not extended to allied equipment or components used in conjunction with our products. **We are not responsible for incidental or consequential damages.** Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

HEATH COMPANY
BENTON HARBOR, MI. 49022

Prices and specifications subject to change without notice.

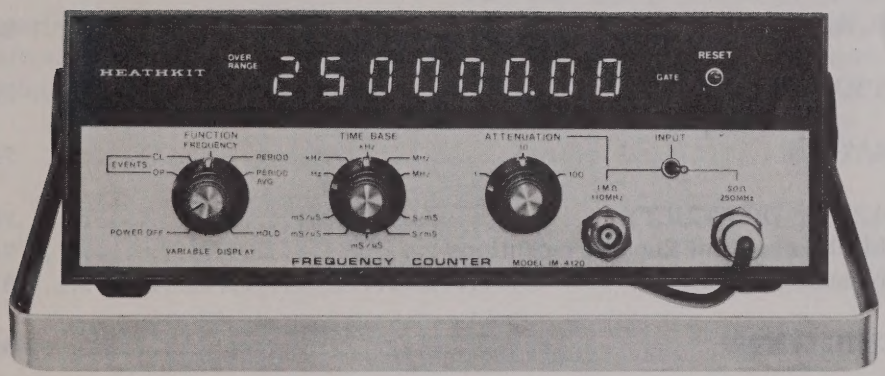
Heathkit® Manual

for the

250 MHz FREQUENCY/ PERIOD METER

Model IM-4120

595-1917-01



HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

Copyright © 1977
Heath Company
All Rights Reserved
Printed in the United States of America

TABLE OF CONTENTS

UNPACKING INSTRUCTIONS 3

ASSEMBLY NOTES 4

MAIN CIRCUIT BOARD
Parts List 7
Step-by-Step Assembly 11

DISPLAY CIRCUIT BOARD
Parts List 28
Step-by-Step Assembly 30

INPUT CIRCUIT BOARD
Parts List 40
Step-by-Step Assembly 42

CHASSIS
Parts List 48
Step-by-Step Assembly 50

INITIAL TESTS 60
Initial Test Difficulties 67

FINAL ASSEMBLY 68

CALIBRATION 72

OPERATION 74

IN CASE OF DIFFICULTY 79
Troubleshooting and Repair Precautions 79
Troubleshooting Chart 81

SPECIFICATIONS 82

CIRCUIT DESCRIPTION
Theory of Operation 85
Detailed Description 86

CIRCUIT BOARD X-RAY VIEWS ..... In the Illustration Booklet

SEMICONDUCTOR IDENTIFICATION CHART 93

SCHEMATIC ..... Fold-in

WARRANTY ..... Inside front cover

CUSTOMER SERVICE ..... Inside rear cover

UNPACKING INSTRUCTIONS

DO NOT UNPACK YOUR KIT UNTIL YOU ARE INSTRUCTED TO DO SO.

Your kit is packed in a single shipping carton. Inside the carton is a box marked PKS 1, 2, & 3. Underneath this box are two packs of parts marked PK4 and PK5, respectively. All the remaining parts are the "Final Pack."

Do not remove any parts from the box or other packs until they are specifically called for in a Parts List. You will be instructed to open each pack as it is needed.

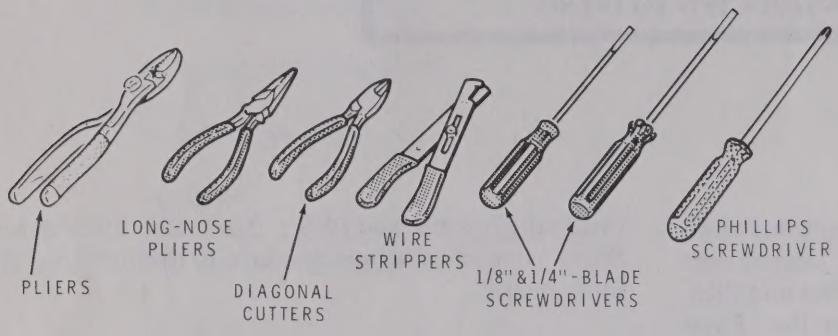
Inside the box marked PKS 1, 2, & 3 is a "Pack Index Sheet" that shows how the box is divided into its three packs.

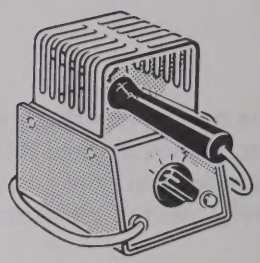
Any part that is packed in an individual envelope with a part number on it should be placed back in the envelope after you identify it until it is called for in a step. Do not discard any packing material until you have accounted for all the parts.

ASSEMBLY NOTES

TOOLS

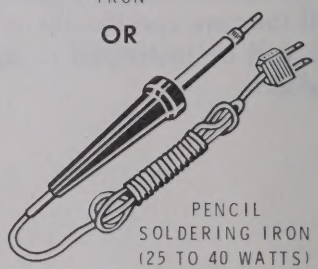
You will need these tools to assemble your kit.





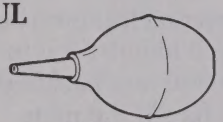
HEATHKIT SOLDERING IRON

OR



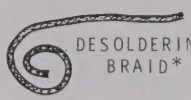
PENCIL SOLDERING IRON (25 TO 40 WATTS)

OTHER HELPFUL TOOLS

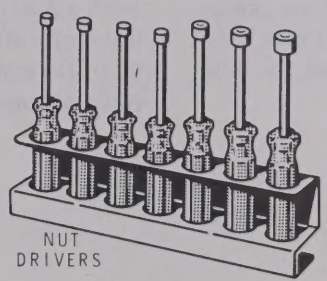


DESOLDERING BULB*

NUT STARTER (MAY BE SUPPLIED WITH KIT)



DESOLDERING BRAID*



NUT DRIVERS

*TO REMOVE SOLDER FROM CIRCUIT CONNECTIONS.

ASSEMBLY

1. Follow the instructions carefully and read the entire step before you perform the operation.

2. The illustrations in the Manual are called Pictorials and Details. Pictorials show the overall operation for a group of assembly steps; Details generally illustrate a single step. When you are directed to refer to a certain Pictorial "for the following steps," continue using that Pictorial until you are referred to another Pictorial for another group of steps.

3. Most kits use a separate "Illustration Booklet" that contains illustrations (Pictorials, Details, etc.) that are too large for the Assembly Manual. Keep the "Illustration Booklet" with the Assembly Manual. The illustrations in it are arranged in Pictorial number sequence.

4. Position all parts as shown in the Pictorials.

5. Solder a part or a group of parts only when you are instructed to do so.

6. When you are instructed to cut something to a particular length, use the scales (rulers) provided at the bottom of the Manual pages.

SAFETY WARNING: Avoid eye injury when you cut off excess lead lengths. Hold the leads so they cannot fly toward your eyes.

SOLDERING

Soldering is one of the most important operations you will perform while assembling your kit. A good solder connection will form an electrical connection between two parts, such as a component lead and a circuit board foil. A bad solder connection could prevent an otherwise well-assembled kit from operating properly.

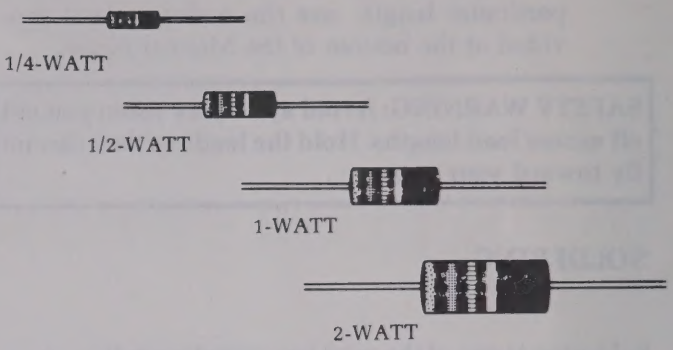
It is easy to make a good solder connection if you follow a few simple rules:

1. Use the right type of soldering iron. A 25 to 40-watt pencil soldering iron with a 1/8" or 3/16" chisel or pyramid tip works best.

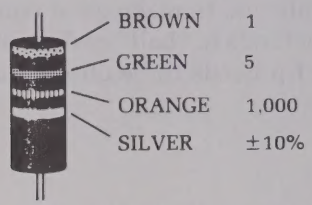
2. Keep the soldering iron tip clean. Wipe it often on a wet sponge or cloth; then apply solder to the tip to give the entire tip a wet look. This process is called tinning, and it will protect the tip and enable you to make good connections. When solder tends to "ball" or does not stick to the tip, the tip needs to be cleaned and retinned.

PARTS

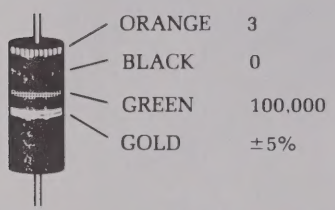
Resistors will be called out by their resistance value in Ω (ohms), kΩ (kilohms), or MΩ (megohms). Certain types of resistors will have the value printed on the body, while others will be identified by a color code. The colors of the bands and the value will be given in the steps, therefore the following color code is given for information only.



EXAMPLES:

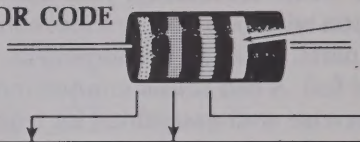


15 × 1,000 = 15,000 Ω (15,000 OHMS), or "15 kΩ"



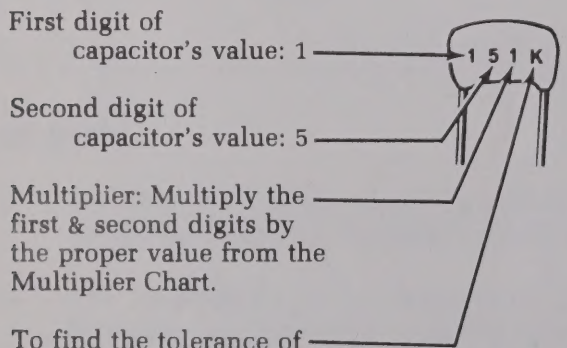
30 × 100,000 = 3,000,000 Ω (or 3 MΩ)
3 MΩ = 3 MEGOHMS

RESISTOR COLOR CODE



COLOR	1st DIGIT	2nd DIGIT	MULTIPLY BY
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	1,000,000,000
GOLD			.1
SILVER			.01

Capacitors will be called out by their capacitance value in μF (microfarads) or pF (picofarads) and type: ceramic, Mylar*, electrolytic, etc. Some capacitors may have their value printed in the following manner:


First digit of capacitor's value: 1
Second digit of capacitor's value: 5
Multiplier: Multiply the first & second digits by the proper value from the Multiplier Chart.
To find the tolerance of the capacitor, look up this letter in the Tolerance columns.
151K

EXAMPLES:

151K = 15 × 10 = 150 pF
759 = 75 × 0.1 = 7.5 pF

NOTE: The letter "R" may be used at times to signify a decimal point; as in: 2R2 = 2.2 (pF or μF).

MULTIPLIER		TOLERANCE OF CAPACITOR		
FOR THE NUMBER:	MULTIPLY BY:	10pF OR LESS	LETTER	OVER 10pF
0	1	±0.1pF	B	
1	10	±0.25pF	C	
2	100	±0.5pF	D	
3	1000	±1.0pF	F	±1%
4	10,000	±2.0pF	G	±2%
5	100,000		H	±3%
			J	±5%
8	0.01		K	±10%
9	0.1		M	±20%

*DuPont Registered Trademark

MAIN CIRCUIT BOARD

PARTS LIST

Remove the box marked "PKS 1, 2, & 3" from the shipping carton. Then open the box and locate the pack index sheet. This box is divided into three packs and the pack index sheet identifies the location of each pack. Do not remove any of the packs until you are instructed to do so.

Remove pack #1 (PK 1) from the box and check the parts against the following parts list and the Main Circuit Board Parts Pictorial (Illustration Booklet, Page 1).

Each circuit part in this kit has its own component number (R2, C4, SW1, etc.). This is a specific number for only that one part. The purpose of these numbers is to help you easily identify the same part in each section of the Manual.

These numbers will appear:

- In the Parts List.
- At the beginning of each step where a component is installed.
- In some illustrations.
- In the sections at the rear of the Manual.

To order a replacement part, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to "Replacement Parts" inside the rear cover of the Manual. Your Warranty is located inside the front cover. For prices, refer to the separate "Heath Parts Price List."

RESISTORS

NOTE: The following resistors are 1/4-watt, 5% (gold fourth band). The resistors may be packed in more than one envelope.

Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-139-12	1	39 Ω (orange-white-black)	R342
A1	1-60-12	1	100 Ω (brown-black-brown)	R341
A1	1-103-12	2	150 Ω (brown-green-brown)	R302, R303
A1	1-63-12	5	270 Ω (red-violet-brown)	R304, R306, R309, R310, R323
A1	1-92-12	5	330 Ω (orange-orange-brown)	R301, R324, R332, R357, R358
A1	1-117-12	14	510 Ω (green-brown-brown)	R305, R307, R308, R311, R312, R314, R315, R316, R317, R318, R320, R322, R355, R356
A1	1-67-12	1	680 Ω (blue-gray-brown)	R345
A1	1-69-12	5	1000 Ω (brown-black-red)	R313, R340, R343, R344, R349
A1	1-72-12	2	2200 Ω (red-red-red)	R359, R360
A1	1-80-12	16	10 kΩ (brown-black-orange)	R325, R327, R328, R329, R330, R331, R333, R334, R335, R336, R337, R338, R339, R346, R347, R365
A1	1-94-12	5	18 kΩ (brown-gray-orange)	R348, R350, R351, R352, R353

CAPACITORS

Ceramic

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A2	21-75	1	100 pF	C339
A2	21-11	1	150 pF	C302
A2	21-17	1	270 pF	C312
A2	21-140	1	.001 μF	C313
A2	21-46	3	.005 μF	C317, C325, C326
A2	21-176	4	.01 μF	C304, C308, C314, C318
A2	21-199	3	.1 μF	C328, C329, C330

Tantalum

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A3	25-220	11	10 μF	C307, C309, C310, C311, C315, C316, C320, C321, C327, C331, C332
A3	25-223	2	47 μF	C319, C324
A3	25-814	3	150 μF	C301, C305, C306

Electrolytic

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A4	25-804	1	100 μF	C322
A5	25-272	2	6000 μF	C337, C338

DIODES

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	56-26	2	1N191 (brown-white-brown)	D306, D307
B1	56-56	9	1N4149	D301, D302, D303, D304, D305, D308, D309, D310, D311
B1	56-59	1	1N750A zener	ZD319
B1	57-42	4	3A1	D314, D315, D316, D317

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

TRANSISTORS

NOTE: Transistors are marked for identification in one of the following four ways:

1. Part number.
2. Type number.
3. Part number and type number.
4. Part number with a type number other than the one listed.

C1	417-293	1	2N5770	Q301
C2	417-801	4	MPSA20	Q302, Q303, Q304, Q305
C3	417-235	1	2N4121	Q306
C4	417-819	2	MJE171	Q307, Q308

INTEGRATED CIRCUITS (IC's)

NOTES:

1. Integrated circuits are marked for identification in one of the following four ways:
   1. Part number.
   2. Type number. (For integrated circuits, this refers only to the numbers; the letters may be different or missing.)
   3. Part number and type number.
   4. Part number with a type number other than the one listed.
2. Several of the IC's are packed in conductive foam. Do not remove the IC's from the foam until you are instructed to do so.
3. After you check the IC's, set them aside and keep them separate from the other parts. They will not be installed until your kit is nearly completed.

D1	442-53	1	NE555V	IC333
D2	443-607	1	CD4013AE	IC319
D2	443-4	1	SN7472	IC340
D2	443-695	1	CD4001	IC318
D2	443-712	1	MC14025	IC320
D2	443-728	5	SN74LS00	IC322, IC324, IC325, IC330, IC342
D2	443-729	1	SN74LS13	IC338
D2	443-730	1	SN74LS74	IC323
D2	443-731	10	SN74LS290	IC313, IC314, IC315, IC326, IC327, IC328, IC329, IC335, IC336, IC337

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Integrated Circuits (cont'd.)

D2	443-732	1	SN74LS30	IC334
D3	443-677	2	MC10211	IC302, IC312
D3	443-723	1	MC10216	IC301
D3	443-724	1	MC10124	IC310
D3	443-725	1	MC10125	IC304
D3	443-726	1	MC10138	IC311
D3	443-727	1	96L02	IC339
D3	443-735	1	MC14512	IC332
D3	443-737	3	MC14518	IC316, IC317, IC321
D3	443-738	1	MC14556	IC309
D4	443-736	4	MC14508	IC305, IC306, IC307, IC308

CONNECTORS — SOCKETS

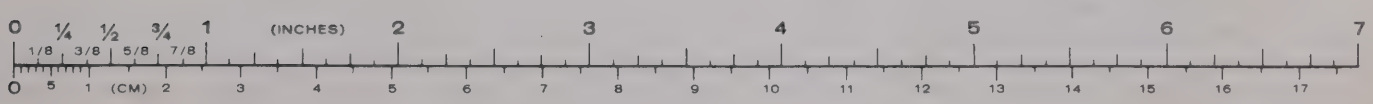
E1	432-134	5	Wire connector
E2	432-734	19	F connector
E3	432-753	2	Socket connector
E4	432-821	1	6-hole socket
E5	432-825	1	6-pin plug
E6	434-230	1	8-pin IC socket
E7	434-298	23	14-pin IC socket
E8	434-299	12	16-pin IC socket
E9	434-307	4	24-pin IC socket

WIRE

344-16	2' 6"	Red stranded wire
344-59	24"	White solid wire
344-81	2' 6"	Violet stranded wire
347-55	2' 6"	8-wire cable

MISCELLANEOUS

F1	51-191	1	Inverter transformer	T301
F2	63-1275	1	Rotary switch with control	SW302/R326/ SW2
F3	63-1276	1	Rotary switch	SW301
	85-1824-6	1	Main circuit board	
F4	250-1237	2	6-32 spacer screw	
F5	254-1	2	#6 lockwasher	
F6	255-724	2	7/8" spacer	
F7	260-65	2	Fuse clip	
F8	262-4	2	Clip pin	
F9	354-7	1	Cable tie	
F10	421-29	1	3/4-ampere, slow-blow fuse	F301
F10	421-42	1	3/8-ampere, slow-blow fuse	F301



KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Remove Pack #4 (packed in the bottom of the shipping carton) and check the parts against the following list.

RESISTORS, 1/4-watt, 5%

A1	1-103-12	1	150 Ω (brown-green-brown)	R321
A1	1-62-12	1	220 Ω (red-red-brown)	R319

CAPACITORS

A2	21-199	1	.1 μF ceramic	C333
A4	25-804	1	100 μF electrolytic	C323

DIODES — IC's — SOCKETS

B1	56-56	2	1N4149 diode	D312, D313
D2	443-733	1	SN74LS293 IC	IC331
D2	443-730	1	SN74LS74 IC	IC341
D3	443-677	1	MC10211 IC	IC303
G1	442-54	1	μA7805	IC346

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

Diodes — IC's — Sockets (cont'd.)

E7	434-298	1	14-pin IC socket
E8	434-299	1	16-pin IC socket

MISCELLANEOUS

G2	150-28	1	TCXO
	343-15	9"	Coaxial cable

PARTS FROM FINAL PACK (in bottom of shipping carton)

391-34	1	Blue and white label
597-260	1	Parts Order Form Manual (See Page 1 for part number.)
		Solder

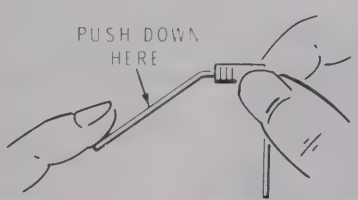
STEP-BY-STEP ASSEMBLY

START

In the following steps, you will be given detailed instructions on how to install and solder the first part on the circuit board. Read and perform each step carefully. Then use the same procedure whenever you install parts on a circuit board.

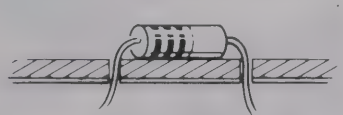
(✓) Position the circuit board as shown with the printed (component) side up.

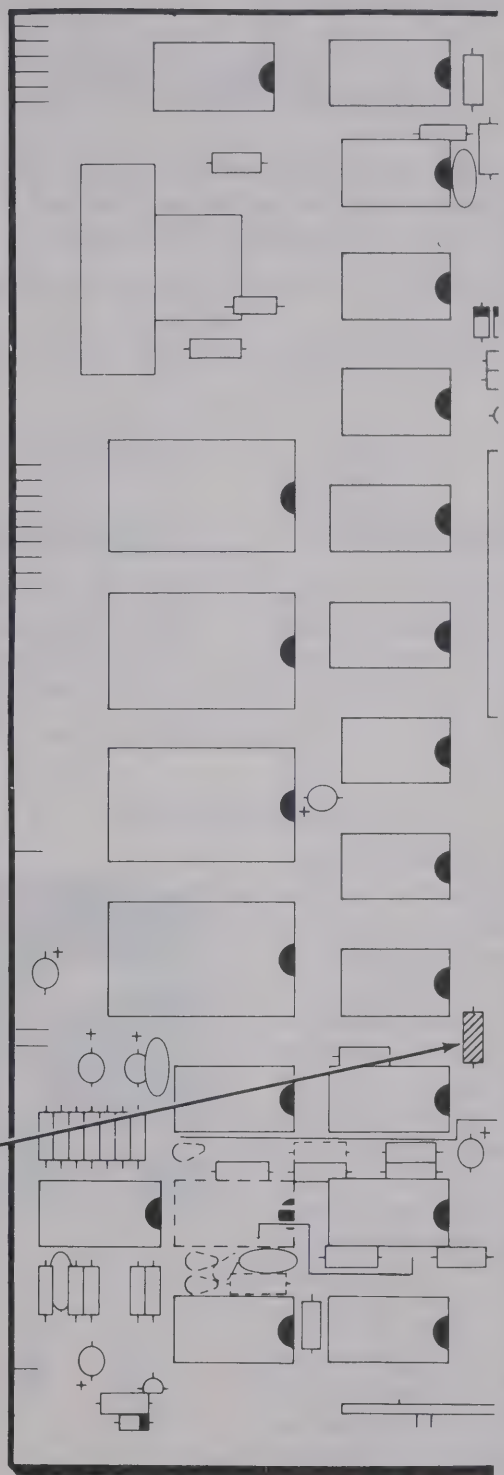
(✓) **R324: Hold a 330 Ω (orange-orange-brown) resistor by the body as shown. Then bend the leads down.**



(✓) Push the leads through the holes at the indicated location on the circuit board. The end with color bands may be positioned either way.

(✓) Press the resistor against the circuit board. Then bend the leads outward slightly to hold the resistor in place.



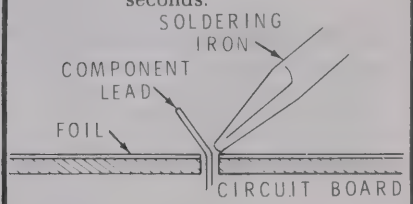


PICTORIAL 1-1

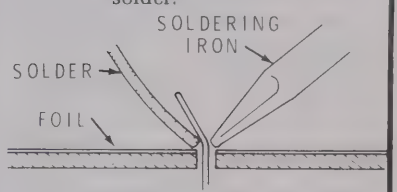
CONTINUE

(✓) Solder the resistor leads to the circuit board as follows:

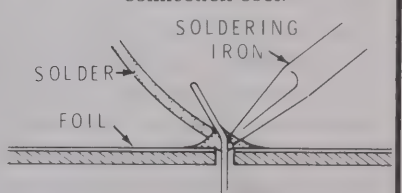
1. Push the soldering iron tip against both the lead and the circuit board foil. Heat **both** for two or three seconds.



2. Then apply solder to the other side of the connection. IMPORTANT: Let the heated lead and the circuit board foil melt the solder.



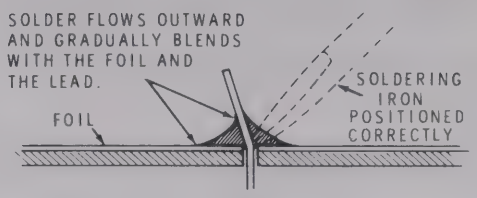
3. As the solder begins to melt, allow it to flow around the connection. Then remove the solder and the iron and let the connection cool.



(✓) Cut off the excess lead lengths close to the connection. WARNING: Clip the leads so the ends will not fly toward your eyes.

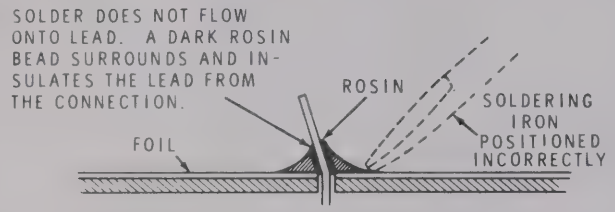
(✓) Check the connection. Compare it to the illustrations on Page 12. After you have checked the solder connections, proceed with the assembly on Page 13. Use the same soldering procedure for each connection.

A GOOD SOLDER CONNECTION

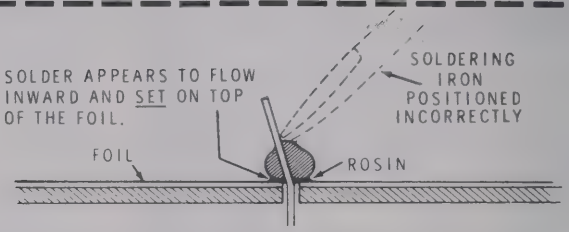


When you heat the lead and the circuit board foil at the same time, the solder will flow evenly onto the lead and the foil. The solder will make a good electrical connection between the lead and the foil.

POOR SOLDER CONNECTIONS


SOLDER DOES NOT FLOW ONTO LEAD. A DARK ROSIN BEAD SURROUNDS AND INSULATES THE LEAD FROM THE CONNECTION.
ROSIN
FOIL
SOLDERING IRON POSITIONED INCORRECTLY

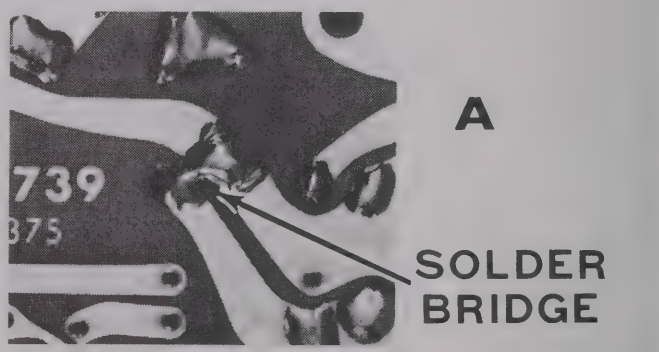
When the lead is not heated sufficiently, the solder will not flow onto the lead as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.



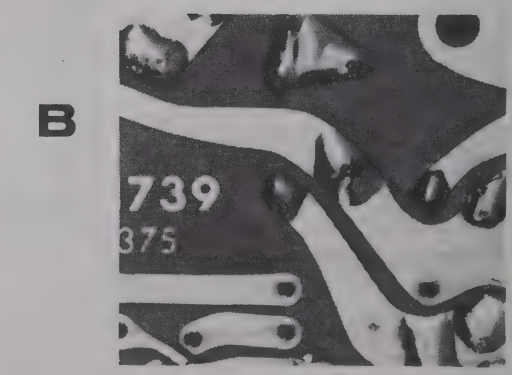
When the foil is not heated sufficiently the solder will blob on the circuit board as shown above. To correct, reheat the connection and, if necessary, apply a small amount of additional solder to obtain a good connection.

SOLDER BRIDGES

A solder bridge between two adjacent foils is shown in photograph **A**. Photograph **B** shows how the connection should appear. A solder bridge may occur if you accidentally touch an adjacent previously soldered connection, if you use too much solder, or if you "drag" the soldering iron across other foils as you remove it from the connection. A good rule to follow is; always take a good look at the foil area around each lead before you solder it. Then, when you solder the connection, make sure the solder remains in this area and does not bridge to another foil. This is especially important when the foils are small and close together. NOTE: It is alright for solder to bridge two connections on the same foil.



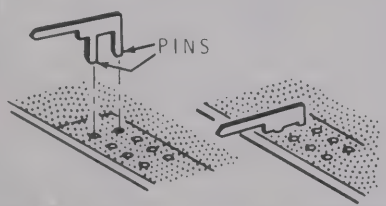
Use only enough solder to make a good connection, and lift the soldering iron straight up from the circuit board. If a solder bridge should develop, turn the circuit board foil-side-down and heat the solder between connections. The excess solder will run onto the tip of the soldering iron, and this will remove the solder bridge.



START

NOTE: There are several locations on the circuit boards where you will not install any parts. There will also be unused circuit board holes. If, after you assemble a circuit board, you have any questions concerning unused locations, recheck the assembly steps.

In the following steps you will install the F connectors. First, from the component side, insert the pins into the circuit board holes and press them in until the connector body rests against the circuit board. Then solder the pins to the foil. Be sure each connector is down against the circuit board.



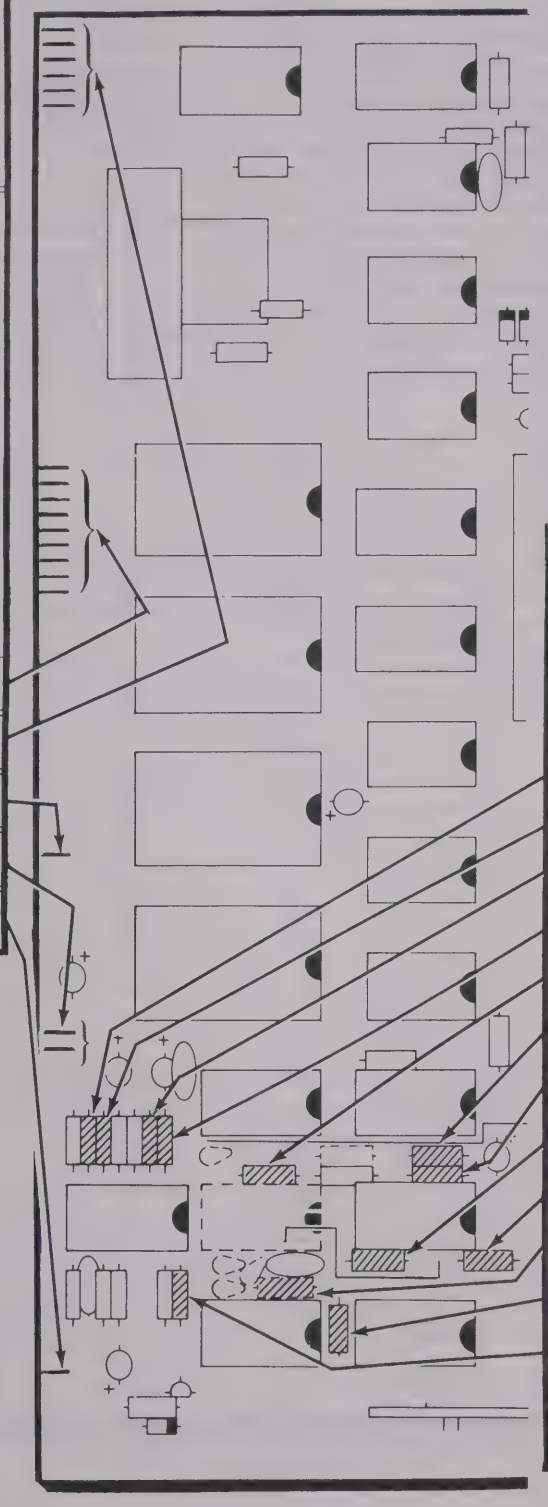
( ) Nine F connectors.

( ) Six F connectors.

( ) One F connector.

( ) Two F connectors.

( ) One F connector.



CONTINUE

Install twelve 510 Ω (green-brown-brown) resistors. BE CAREFUL. DO NOT install any 150 Ω (brown-green-brown) resistors.

( ) R307.

( ) R308.

( ) R311.

( ) R312.

( ) R318.

( ) R322.

( ) R320.

( ) R316.

( ) R317.

( ) R314.

( ) R315.

( ) R305.

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-2

START

Install thirteen 10 kΩ (brown-black-orange) resistors.

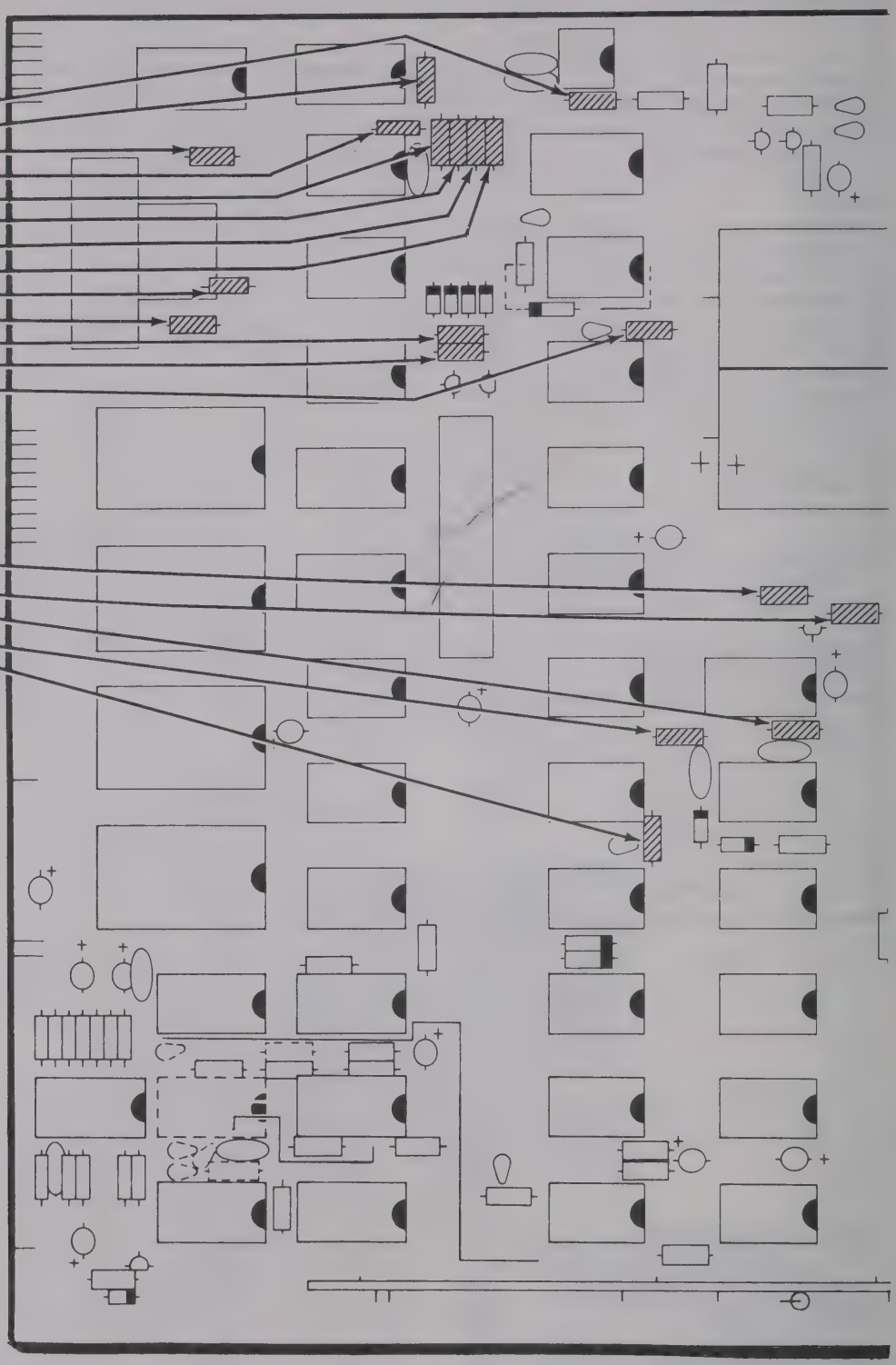
( ) R339 .....
( ) R338 .....
( ) R328 .....
( ) R333 .....
( ) R334 .....
( ) R335 .....
( ) R336 .....
( ) R337 .....
( ) R327 .....
( ) R325 .....
( ) R330 .....
( ) R329 .....
( ) R331 .....

( ) Solder the leads to the foil and cut off the excess lead lengths.

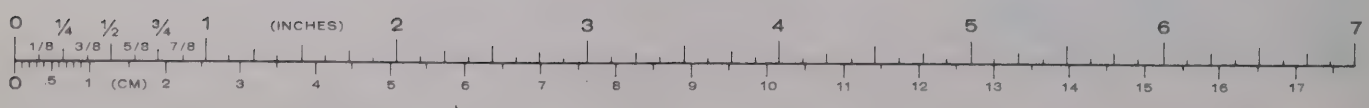
Install five 18 kΩ (brown-gray-orange) resistors.

( ) R352 .....
( ) R353 .....
( ) R351 .....
( ) R350 .....
( ) R348 .....

( ) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-3



HEATHKIT®

START

( ) R341: 100 Ω (brown-black-brown).

( ) R340: 1000 Ω (brown-black-red).

( ) R342: 39 Ω (orange-white-black).

( ) R343: 1000 Ω (brown-black-red).

( ) Solder the leads to the foil and cut off the excess lead lengths.

When a wire is called for, cut it to the indicated length and remove 1/4" of insulation from the wire ends. Solder each wire as you install it.

( ) 3/4" white solid wire as shown. NOTE: You will **not** install a 330 Ω resistor at the resistor location, nor a diode at ZD318.

(X) Do not install a wire here.

( ) 3/4" white solid wire as shown.

( ) R323: 270 Ω (red-violet-brown).

( ) R321: 150 Ω (brown-green-brown).

( ) R319: 220 Ω (red-red-brown).

Install four 270 Ω (red-violet-brown) resistors.

( ) R310 .....

( ) R309 .....

( ) R306 .....

( ) R304 .....

( ) R303: 150 Ω (brown-green-brown).

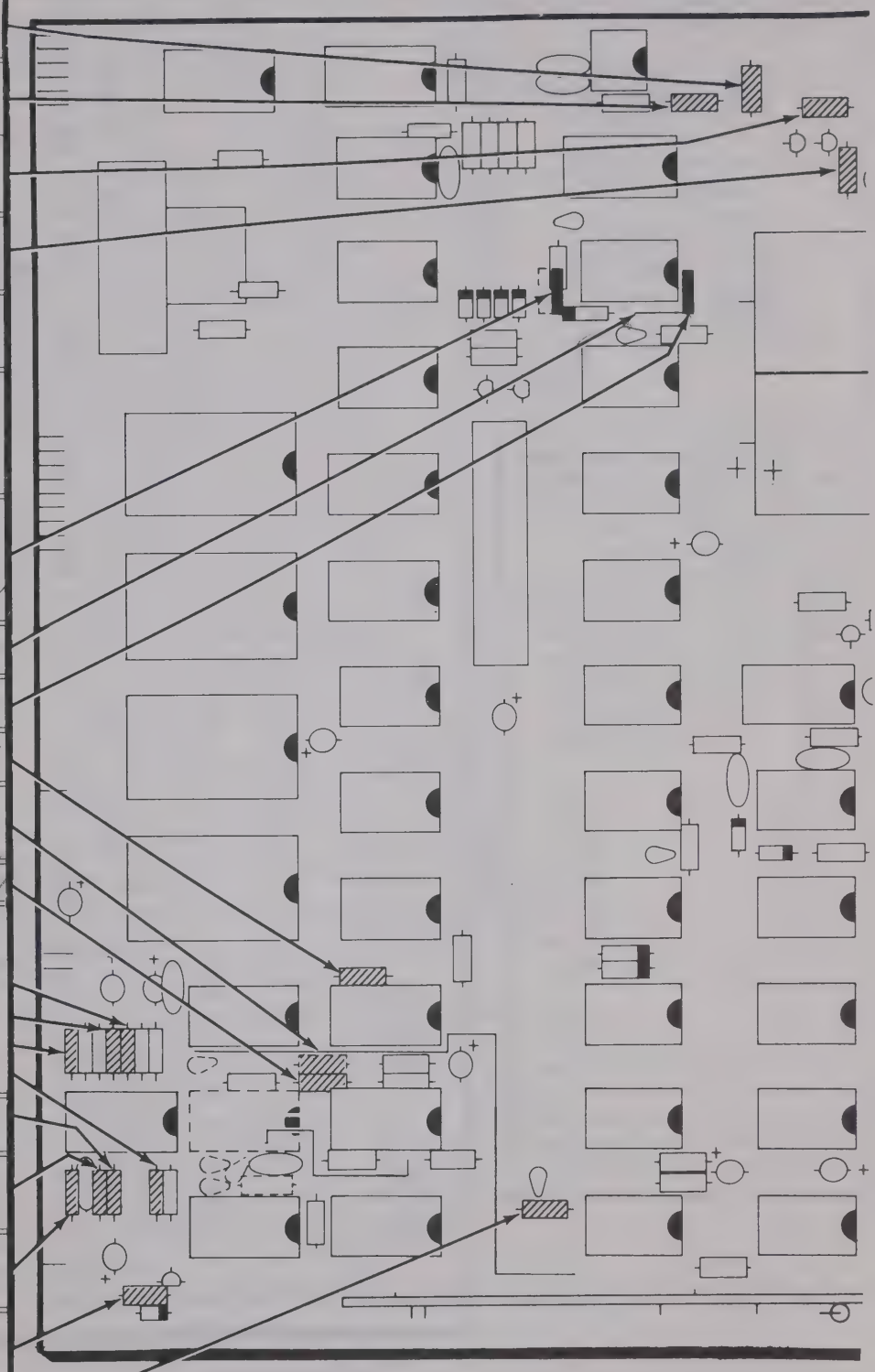
( ) R302: 150 Ω (brown-green-brown).

( ) R301: 330 Ω (orange-orange-brown).

( ) R313: 1000 Ω (brown-black-red).

( ) R344: 1000 Ω (brown-black-red).

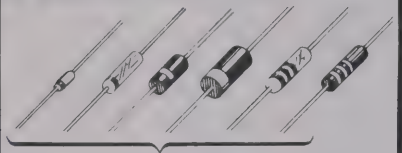
( ) Solder the leads to the foil and cut off the excess lead lengths.



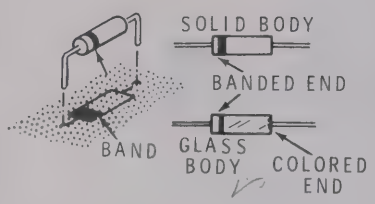
PICTORIAL 1-4

START

IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.



BANDED END



If your diode has a solid body, the band is clearly defined. If your diode has a glass body, do not mistake the colored end inside the diode for the banded end. Look for a band painted on the outside of the glass.

NOTE: When you install diodes, as in the following steps, be sure you position the banded end of each diode as it is shown on the circuit board.

Install six 1N4149 diodes (#56-56).

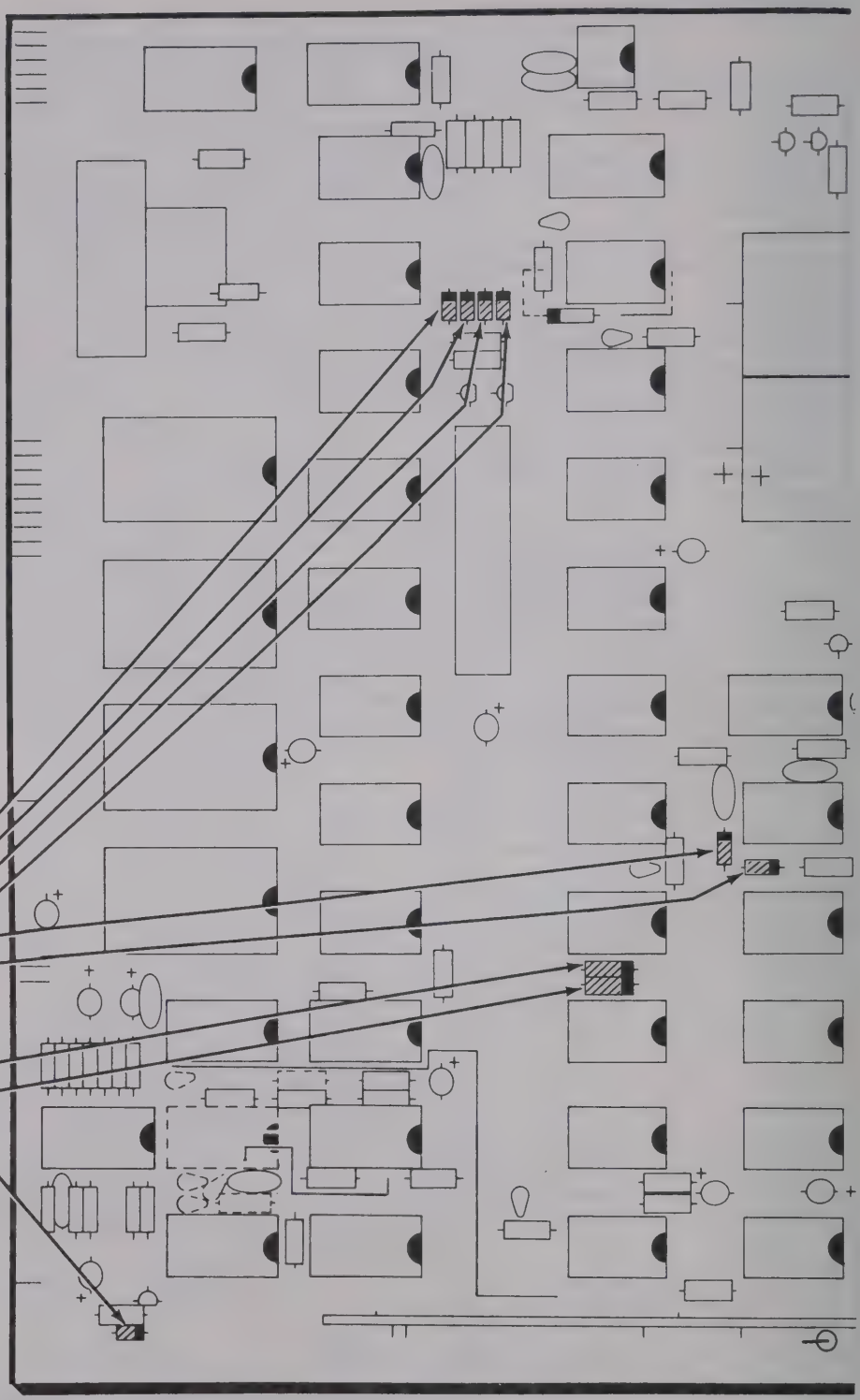
( ) D302
( ) D303
( ) D304
( ) D305
( ) D309
( ) D308

Install two 1N191 diodes (#56-26), (brown-white-brown).

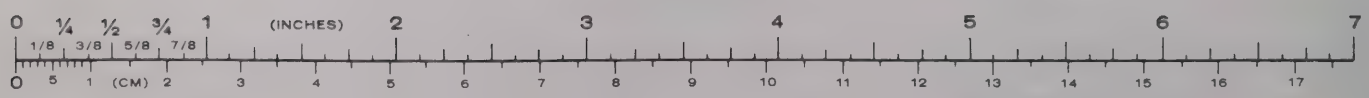
( ) D307
( ) D306

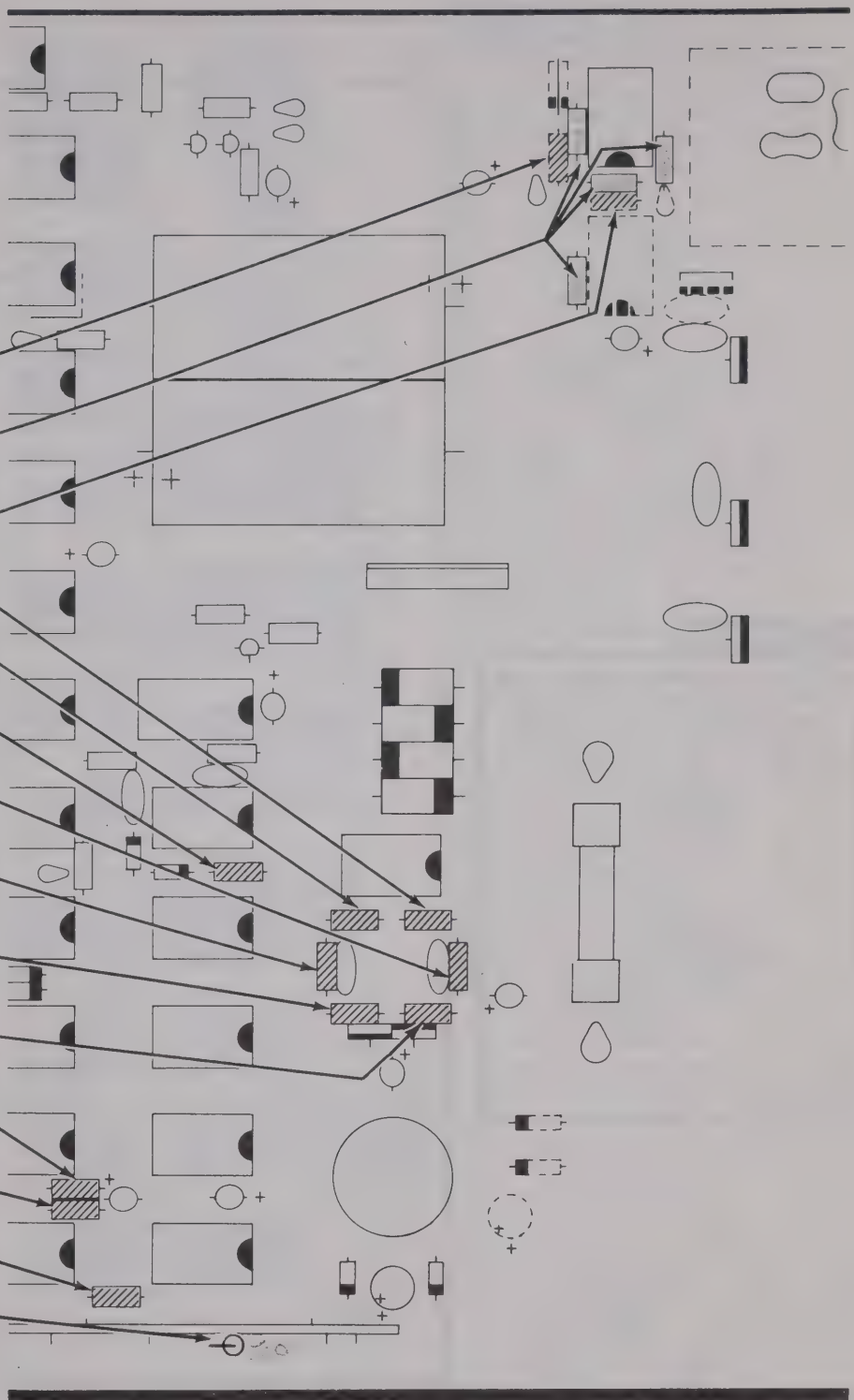
( ) D301: 1N4149 diode (#56-56).

( ) Solder the leads to the foil and cut off the excess lead lengths.



PICTORIAL 1-5

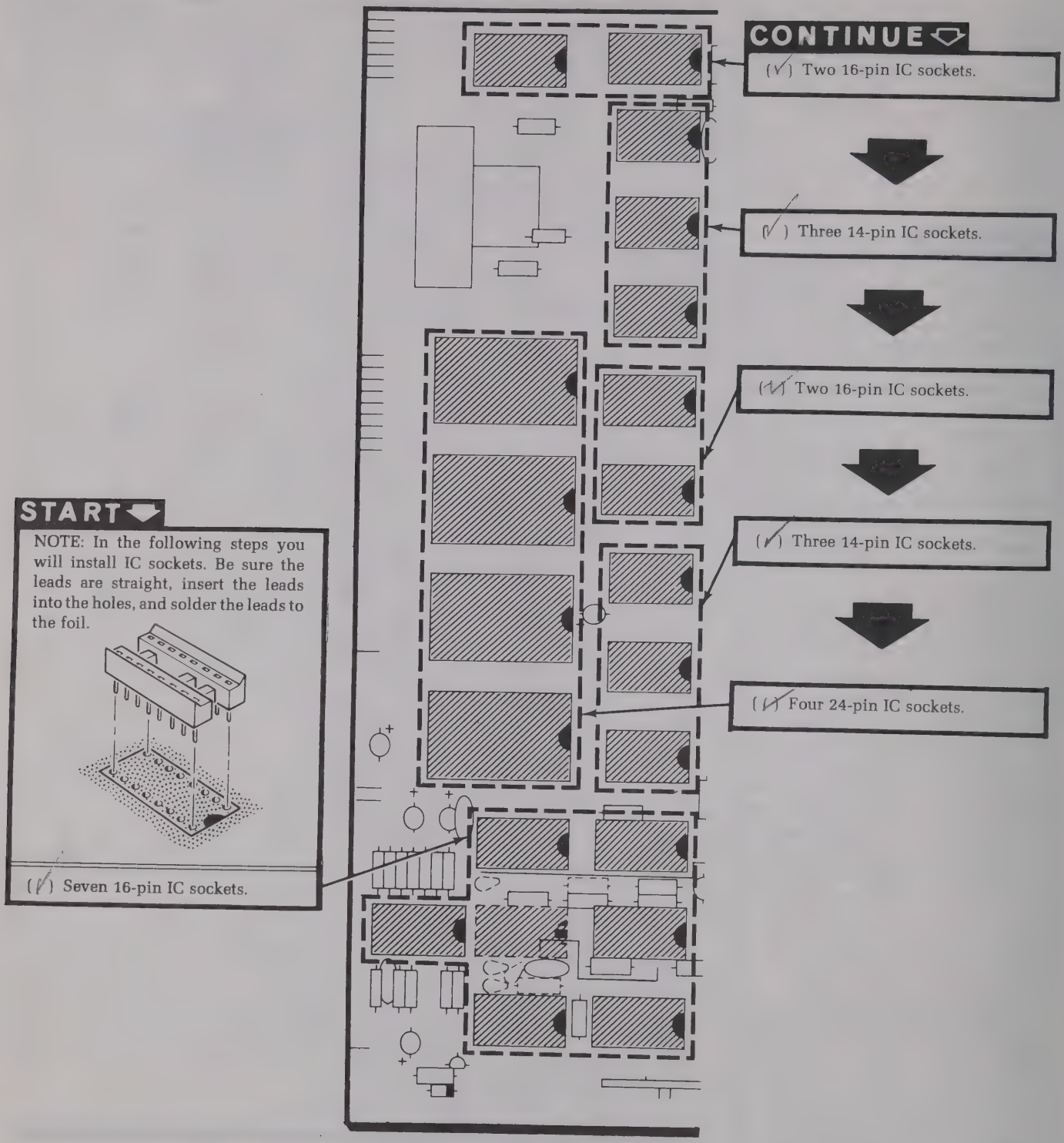




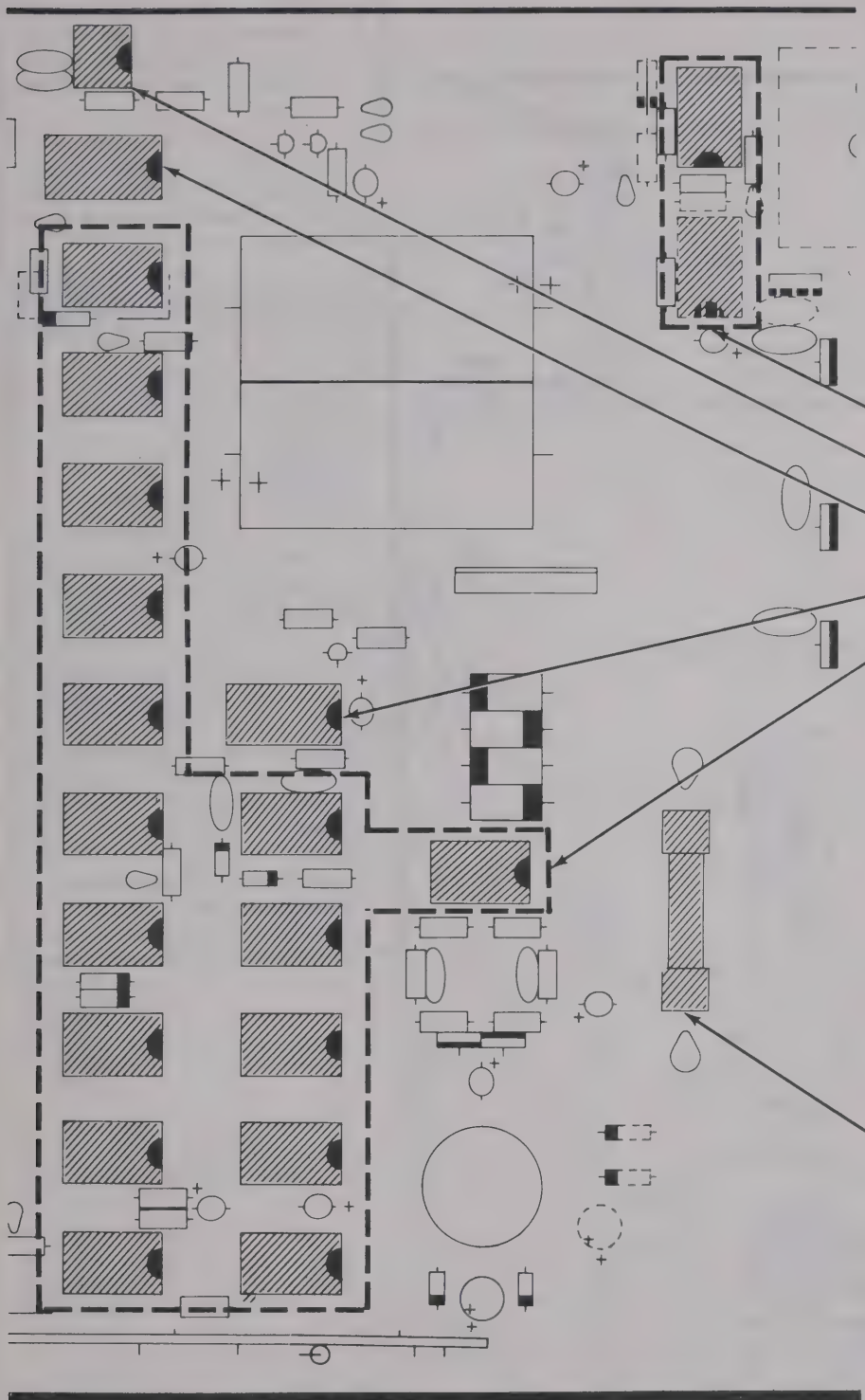
START

- ( ) R332: 330 Ω (orange-orange-brown).
- ( ) Do not install resistors at these four locations.
- ( ) R365:10 kΩ (brown-black-orange).
- ( ) R360: 2200 Ω (red-red-red).
- ( ) R359: 2200 Ω (red-red-red).
- ( ) R349: 1000 Ω (brown-black-red).
- ( ) R358: 330 Ω (orange-orange-brown).
- ( ) R357: 330 Ω (orange-orange-brown).
- ( ) R355: 510 Ω (green-brown-brown).
- ( ) R356: 510 Ω (green-brown-brown).
- ( ) R347: 10 kΩ (brown-black-orange).
- ( ) R346: 10 kΩ (brown-black-orange).
- ( ) R345: 680 Ω (blue-gray-brown).
- ( ) Do not install a resistor here.
- ( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-6

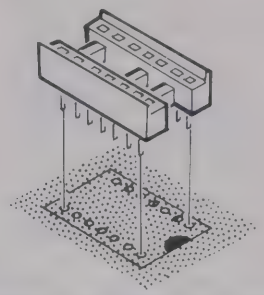

START
NOTE: In the following steps you will install IC sockets. Be sure the leads are straight, insert the leads into the holes, and solder the leads to the foil.
( ) Seven 16-pin IC sockets.
CONTINUE
( ) Two 16-pin IC sockets.
( ) Three 14-pin IC sockets.
( ) Two 16-pin IC sockets.
( ) Three 14-pin IC sockets.
( ) Four 24-pin IC sockets.

PICTORIAL 1-7



START

NOTE: When you install IC sockets in the following steps, be sure the leads are straight, insert the leads into the holes, and solder the leads to the foil.



( ) Two 14-pin IC sockets.

( ) 8-pin IC socket.

( ) 16-pin IC socket.

( ) 16-pin IC socket.

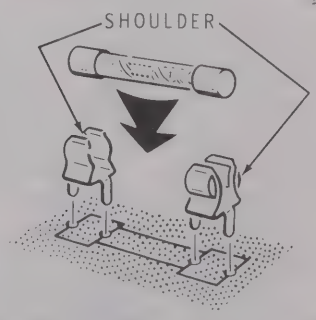
( ) Sixteen 14-pin IC sockets.

NOTE: Two fuses are supplied with this kit, a 3/4-ampere for 120 VAC line voltage and a 3/8-ampere for 240 VAC line voltage.

In the following steps, use only the fuse that agrees with the line voltage in your area. 3/4 A

( ) First install the fuse clips in the circuit board. Be sure to position the fuse clip shoulders as shown. Do not solder the clips to the foil.

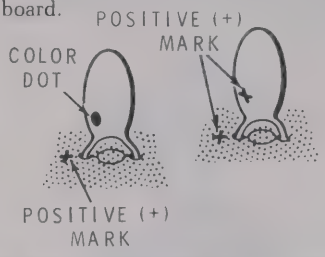
( ) F301: Install the fuse into the fuse clip. Then solder the fuse clip lugs to the foil.



PICTORIAL 1-8

START

NOTE: When you install tantalum capacitors, be sure to position the plus (+) or color dot marked lead in the plus marked hole in the circuit board.

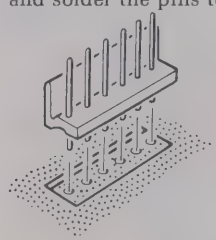


( ) C332: 10 μF tantalum.

( ) C331: 10 μF tantalum.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) 6-pin plug. Install it as shown and solder the pins to the foil.



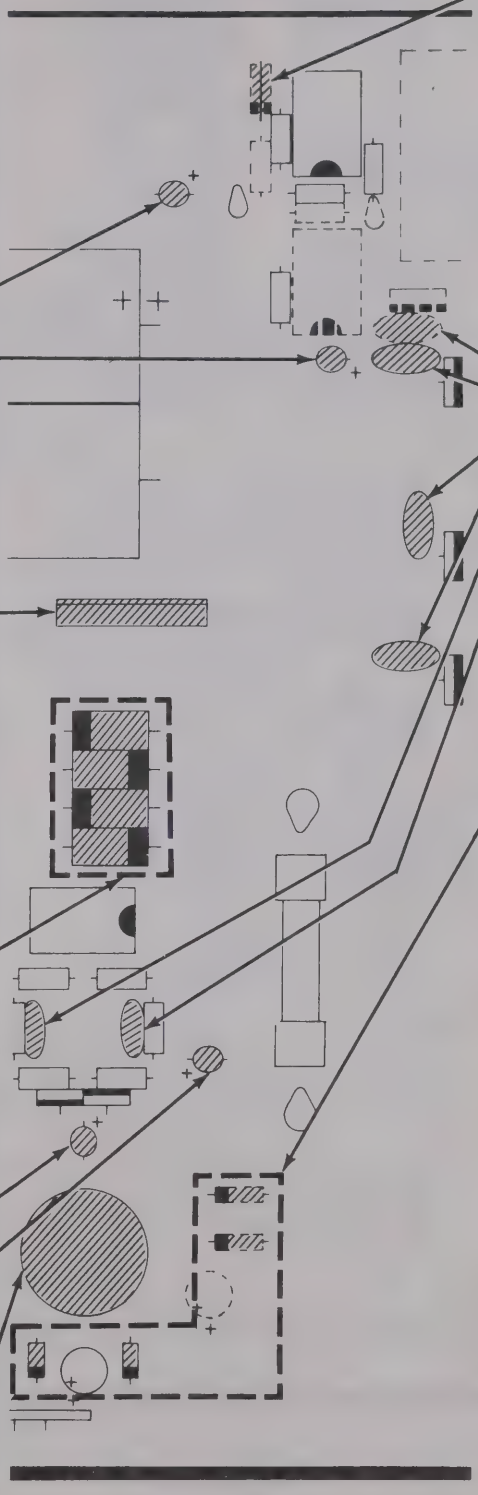
( ) Install four 3A1 diodes (#57-42) at D317, D316, D315, and D314. Position the banded ends as shown on the circuit board and mount each diode 1/4" off the circuit board. Solder each diode as you install it.

( ) C324: 47 μF tantalum.

( ) C327: 10 μF tantalum.

( ) Solder the leads to the foil and cut off the excess lead lengths.

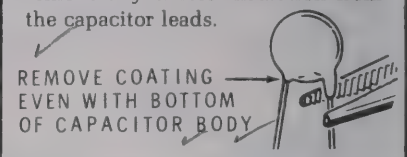
( ) T301: Inverter transformer. Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) ZD319: 1N750A zener diode (#56-59). Position the banded end as shown on the circuit board. (Do **not** install a wire here.)

NOTE: Before you install ceramic capacitors, use long-nose pliers to remove any excess insulation from the capacitor leads.



Install four .1 μF ceramic capacitors.
( ) C333.
( ) C330.
( ) C329.
( ) C328.

( ) C325: .005 μF ceramic.

( ) C326: .005 μF ceramic.

( ) Solder the leads to the foil and cut off the excess lead lengths.

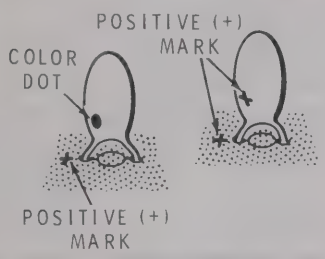
( ) Install four 1N4149 diodes (#56-56) at D313, D312, D311, and D310. Position the banded ends as shown on the circuit board.

( ) Solder the leads to the foil and cut off the excess lead length.

PICTORIAL 1-9

START

( ) C321: 10 μF tantalum.



( ) C320: 10 μF tantalum.

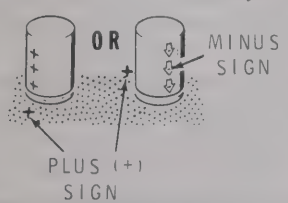
( ) C319: 47 μF tantalum.

( ) C318: .01 μF ceramic.

( ) C317: .005 μF ceramic.

NOTE: When you install an electrolytic capacitor, be sure to position the plus (+) marked lead in the plus marked hole in the circuit board.

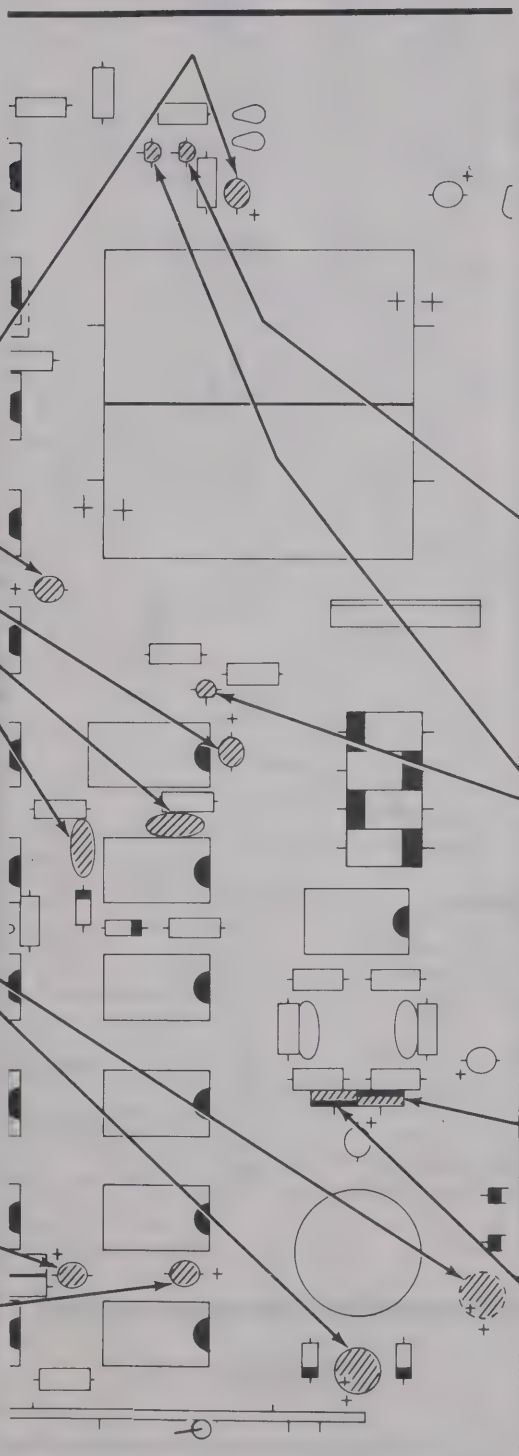
Install two 100 μF electrolytic capacitors.
( ) C323. .....
( ) C322 .....



( ) C315: 10 μF tantalum.

( ) C316: 10 μF tantalum.

( ) Solder the leads to the foil and cut off the excess lead lengths.



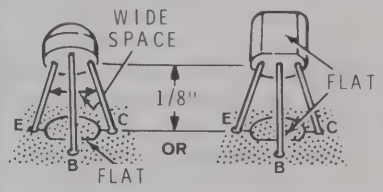
CONTINUE

NOTE: When you install a transistor:

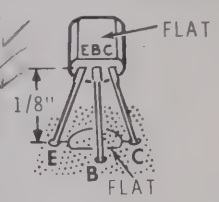
1. Refer to the illustration and identify the E, B, and C leads of the transistor.
2. Bend the center lead of the transistor as shown.
3. Insert the transistor leads into the corresponding E, B, and C holes in the circuit board.
4. Position the transistor 1/8" above the circuit board.
5. Turn the circuit board over, solder the leads to the foil, and cut off the excess lead lengths.

( ) Q306: 2N4121 transistor (#417-235).

WIDE SPACE BETWEEN LEADS IS AWAY FROM FLAT



Install two MPSA20 transistors (#417-801).
( ) Q305.
( ) Q304.

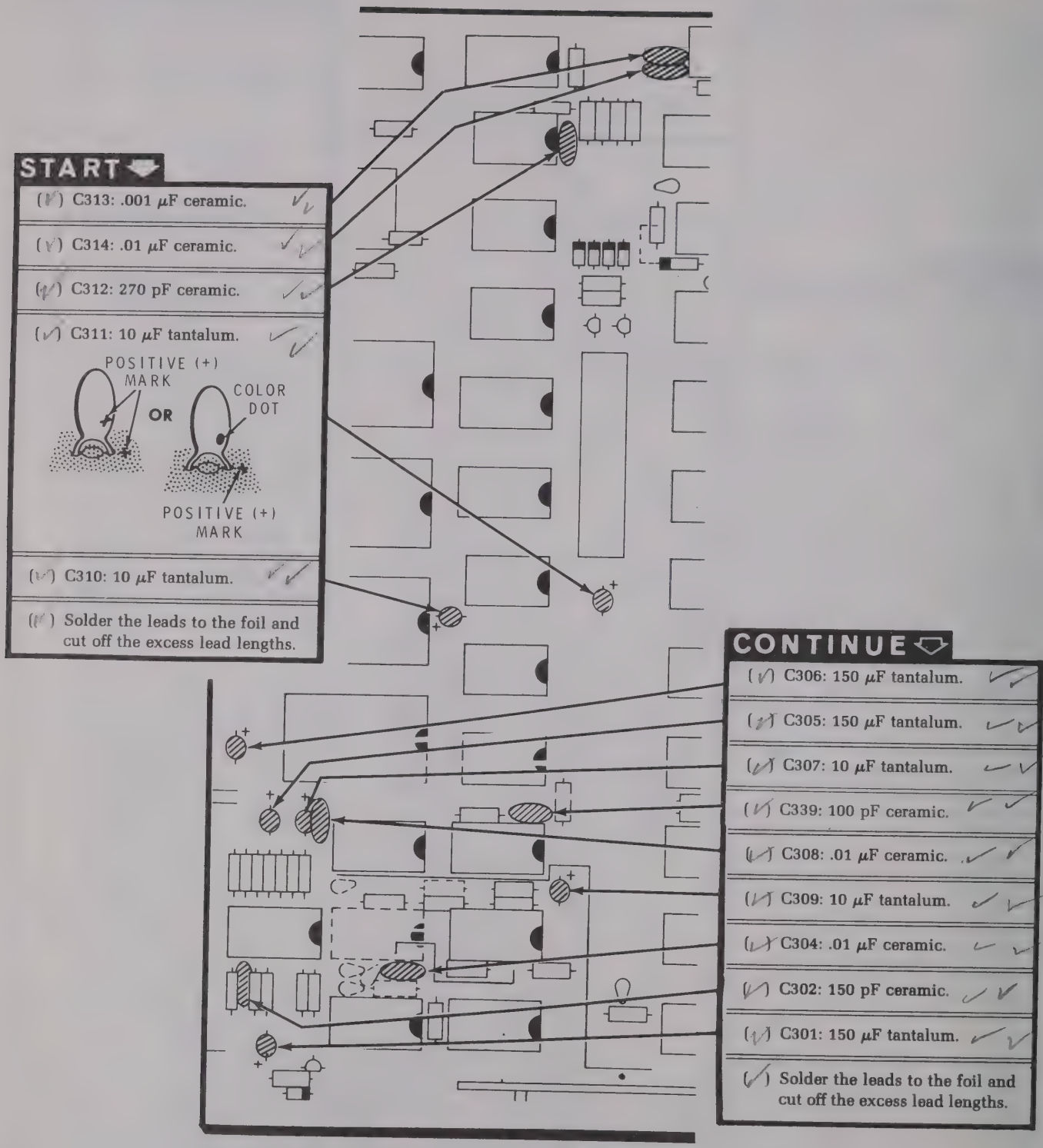


CENTER LEAD FORWARD

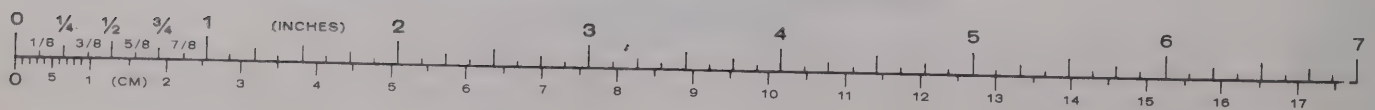
( ) Q308: MJE171 transistor (#417-819).

( ) Q307: MJE171 transistor (#417-819).

PICTORIAL 1-10


START
( ) C313: .001 μF ceramic.
( ) C314: .01 μF ceramic.
( ) C312: 270 pF ceramic.
( ) C311: 10 μF tantalum.
POSITIVE (+) MARK
OR
COLOR DOT
POSITIVE (+) MARK
( ) C310: 10 μF tantalum.
( ) Solder the leads to the foil and cut off the excess lead lengths.
CONTINUE
( ) C306: 150 μF tantalum.
( ) C305: 150 μF tantalum.
( ) C307: 10 μF tantalum.
( ) C339: 100 pF ceramic.
( ) C308: .01 μF ceramic.
( ) C309: 10 μF tantalum.
( ) C304: .01 μF ceramic.
( ) C302: 150 pF ceramic.
( ) C301: 150 μF tantalum.
( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 1-11



START

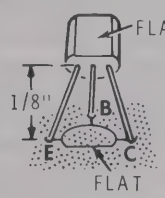
NOTE: When you install a transistor:

1. Refer to the illustration and identify the E, B, and C leads of the transistor.
2. Bend the center lead of the transistor as shown.
3. Insert the transistor leads into the corresponding E, B, and C holes in the circuit board.
4. Position the transistor 1/8" above the circuit board.
5. Turn the circuit board over, solder the leads to the foil, and cut off the excess lead lengths.

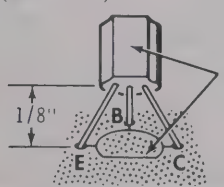
Install two MPSA20 transistors (#417-801).

(✓) Q302 . . . . . ✓

(✓) Q303 . . . . . ✓



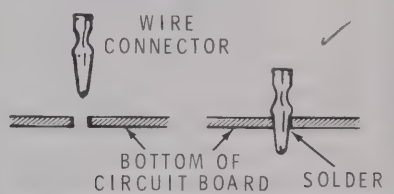
(✓) Q301: 2N5770 transistor (#417-293).



CONTINUE

In the following steps, you will install five wire connectors. Solder each wire connector as you install it.

(✓) Wire connector at B.



(✓) Wire connector at C.

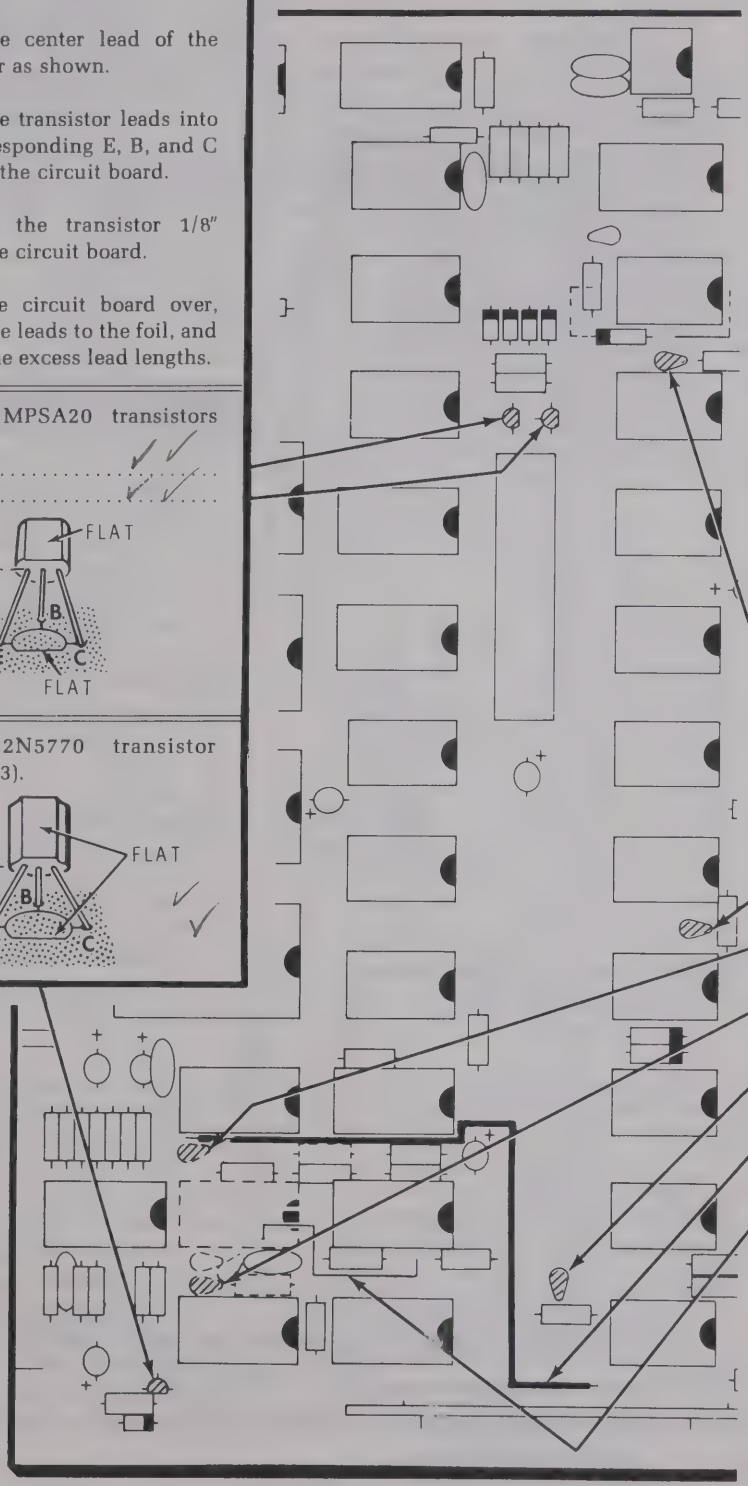
(✓) Wire connector at A.

(✓) Wire connector at F.

(✓) Wire connector at G.

(✓) 5" white solid wire. Route the wire as shown.

(✓) Do not install a wire here.



PICTORIAL 1-12

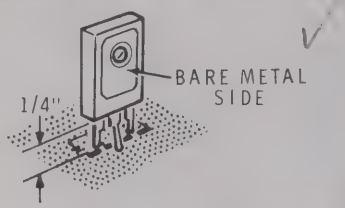
START

( ) Do **not** install these four parts.

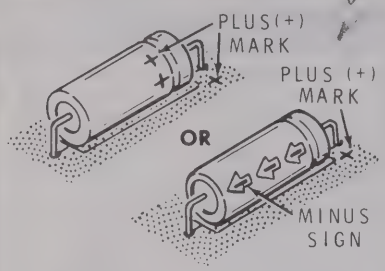
NOTE: As you install the following parts and wires, solder them to the foil and cut off the excess lead lengths.

( ) TCXO. INSTALL

( ) IC346: μA7805 IC (#442-54).

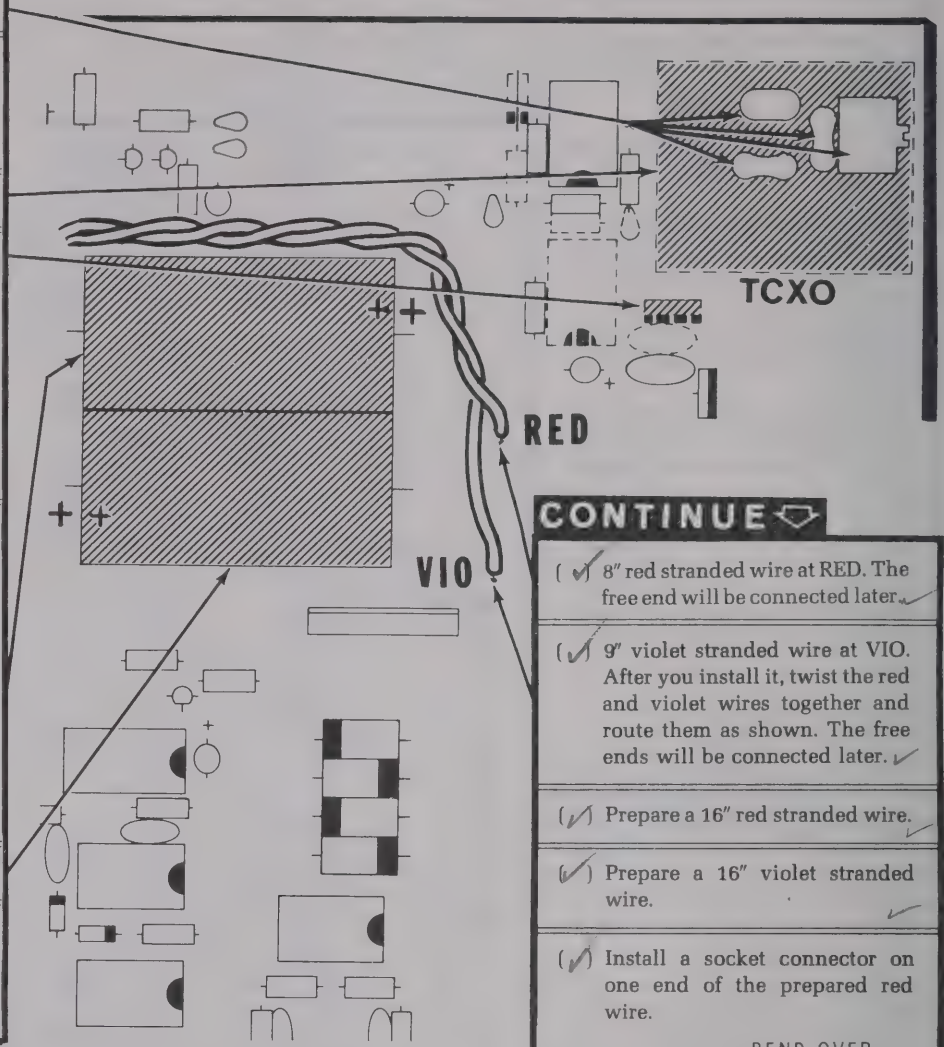


( ) C337: 6000 μF electrolytic.



( ) C338: 6000 μF electrolytic.

NOTE: When you prepare a stranded wire, twist together the bare ends and melt a small amount of solder on them to hold the strands together.



CONTINUE

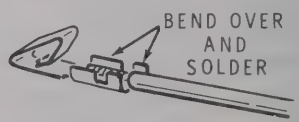
( ) 8" red stranded wire at RED. The free end will be connected later.

( ) 9" violet stranded wire at VIO. After you install it, twist the red and violet wires together and route them as shown. The free ends will be connected later.

( ) Prepare a 16" red stranded wire.

( ) Prepare a 16" violet stranded wire.

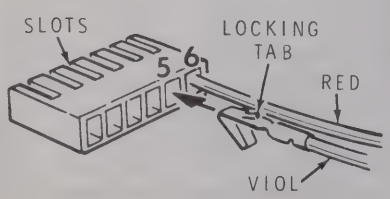
( ) Install a socket connector on one end of the prepared red wire.



( ) Install a socket connector on one end of the prepared violet wire.

( ) Refer to Detail 1-13A and prepare the 6-hole socket.

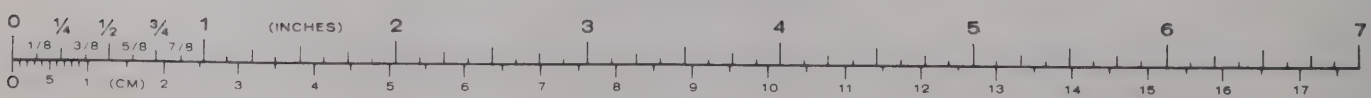
( ) Twist the two wires together (as before) and set the assembly aside temporarily.

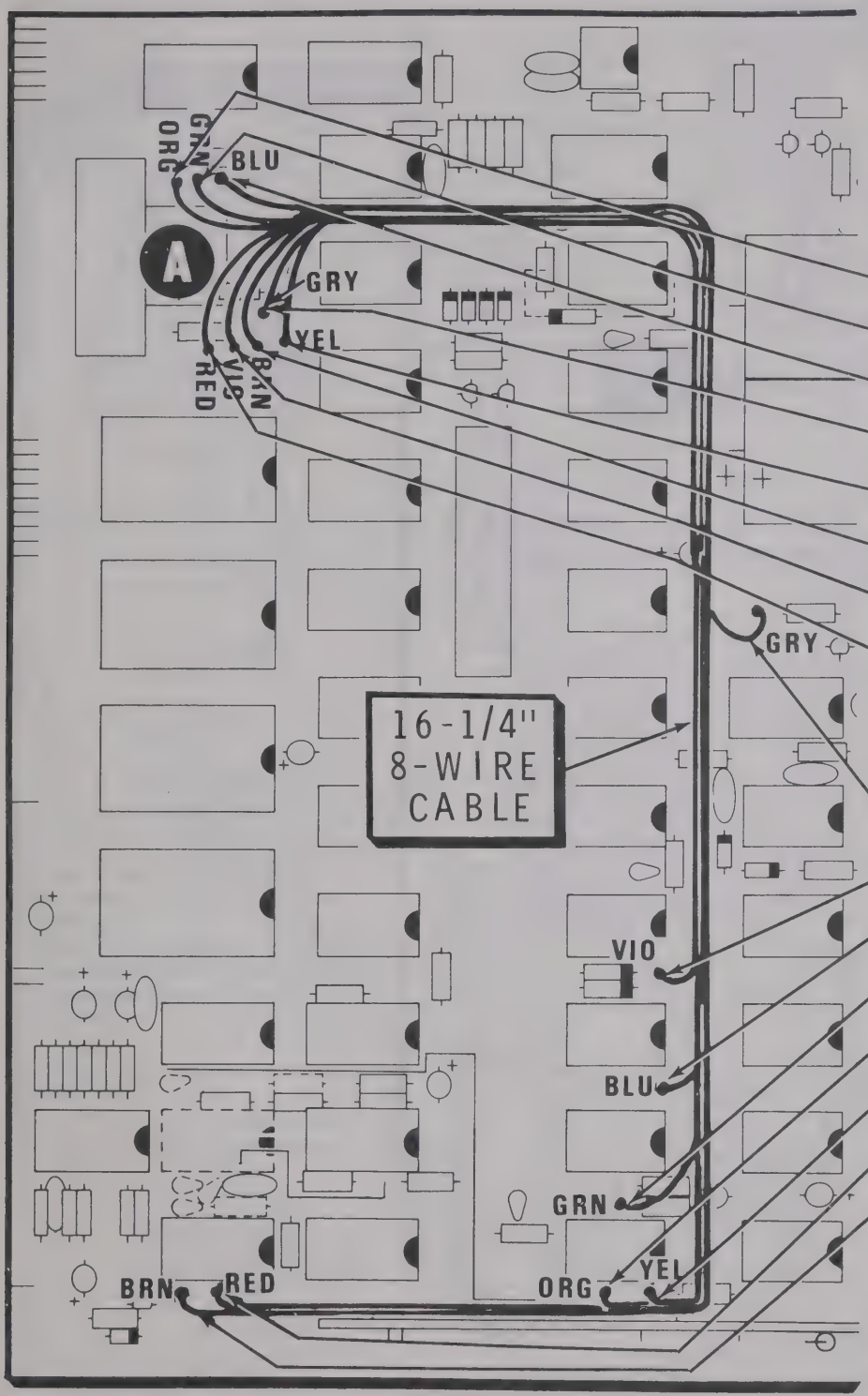


1. Position the socket so its slots are up as shown.
2. Position the connector on the violet wire so its locking tab is up as shown.
3. Push the connector into socket hole #5 until the connector locks in place.
4. In a similar manner, install the connector pin on the red wire into socket hole #6.

Detail 1-13A

PICTORIAL 1-13





START

( ) Refer to Detail 1-14A (Illustration Booklet, Page 2) and prepare a 16-1/4" length of 8-wire cable as shown. See the inset drawing and use diagonal cutters or a knife to start separating the wires.

Connect the wires at end A of the 8-wire cable as follows. Solder each wire as you install it.

( ) Orange to hole ORG.

( ) Green to hole GRN.

( ) Blue to hole BLU.

( ) Gray to hole GRY.

( ) Yellow to hole YEL.

( ) Brown to hole BRN.

( ) Violet to hole VIO.

( ) Red to hole RED.

In the following steps, connect the remaining cable wires. Route the cable as shown.

( ) Gray to hole GRY.

( ) Violet to hole VIO.

( ) Blue to hole BLU.

( ) Green to hole GRN.

( ) Orange to hole ORG.

( ) Yellow to hole YEL.

( ) Red to hole RED.

( ) Brown to hole BRN.

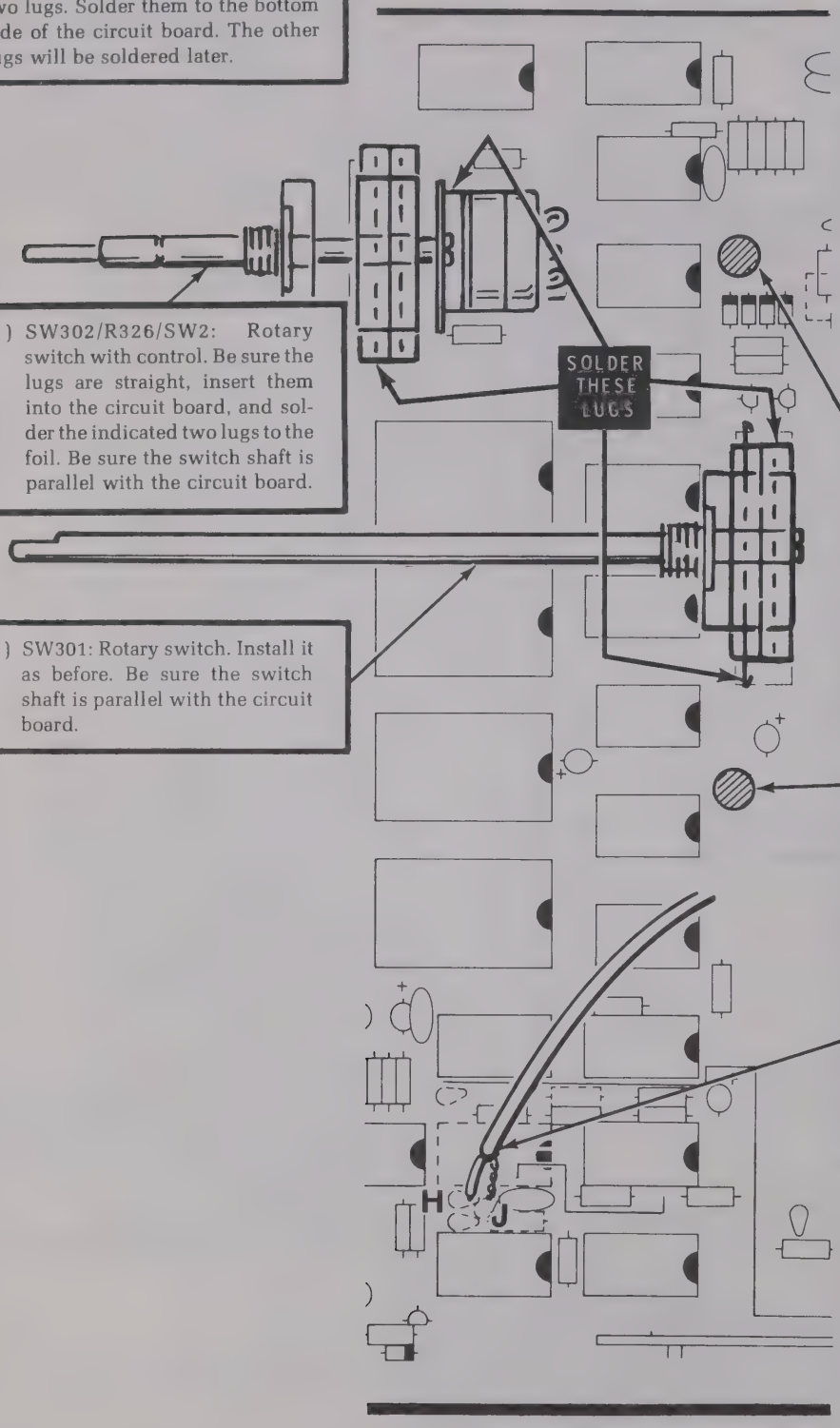
PICTORIAL 1-14

START

NOTE: When you install the next two switches, only solder the indicated two lugs. Solder them to the bottom side of the circuit board. The other lugs will be soldered later.

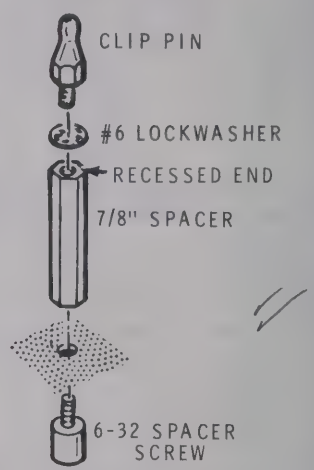
( ) SW302/R326/SW2: Rotary switch with control. Be sure the lugs are straight, insert them into the circuit board, and solder the indicated two lugs to the foil. Be sure the switch shaft is parallel with the circuit board.

( ) SW301: Rotary switch. Install it as before. Be sure the switch shaft is parallel with the circuit board.



CONTINUE

(✓) Mount a clip pin, #6 lockwasher, 7/8" spacer, and 6-32 spacer screw as shown. Position the recessed end of the spacer as shown.



(✓) In a similar manner, mount another clip pin, #6 lockwasher, 7/8" spacer, and 6-32 spacer screw.

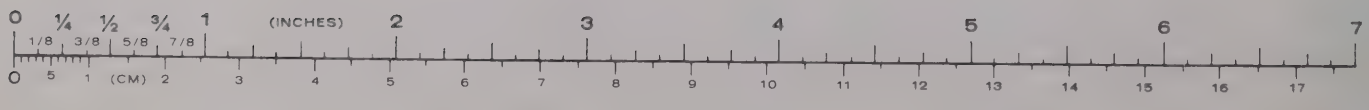
(✓) Refer to Detail 1-15A (in the Illustration Booklet) and prepare a 6" coaxial cable as shown.

(✓) Connect either end of the cable as follows and solder the leads to the foil. The free end will be connected later.

✓ Inner lead to hole H.

✓ Shield lead to hole J.

PICTORIAL 1-15



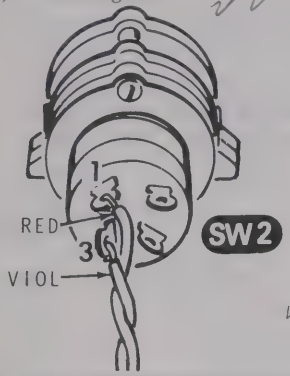
HEATHKIT®

START

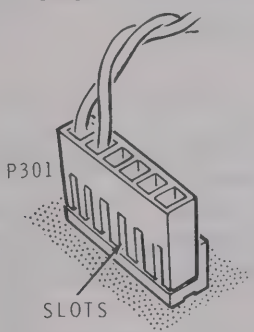
( ) Reposition the circuit board as shown.

Connect the twisted red and violet circuit board wires to switch SW2 as follows. Solder each wire as you connect it.

( ) Violet to lug 3.
( ) Red to lug 1.

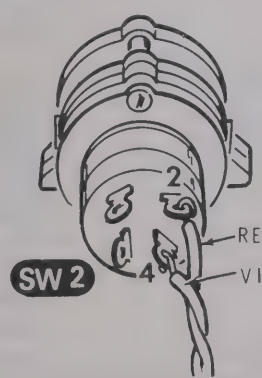


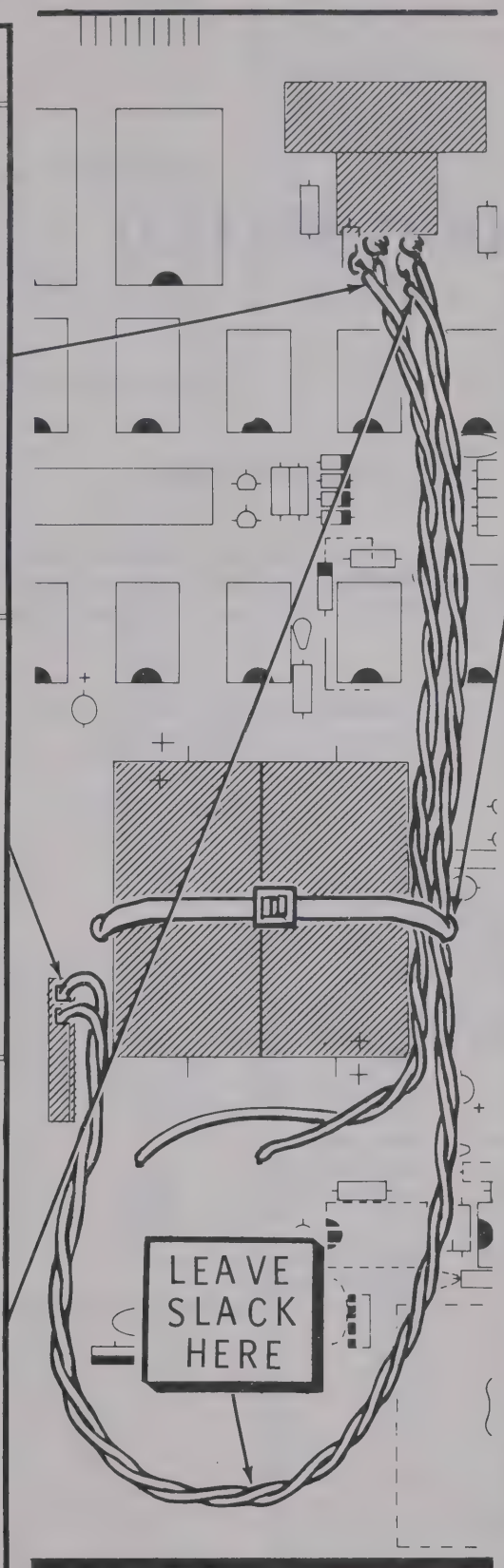
( ) Locate the socket assembly you set aside earlier. Position the socket so its slots are as shown and plug it in at P301.



Connect the remaining twisted red and violet wires to switch SW2 as follows. Solder each wire as you connect it. Do **not** shorten either of these wires.

( ) Violet to lug 4.
( ) Red to lug 2.

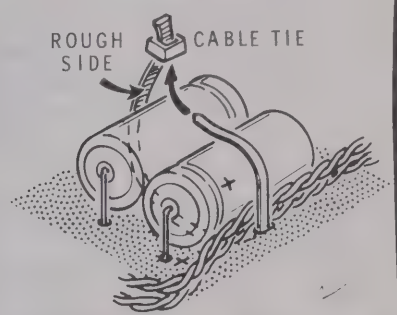




PICTORIAL 1-16

CONTINUE

( ) Secure these two capacitors and the two twisted pairs of wires with a cable tie as shown (with the rough side of the cable tie on the inside). Leave the slack of the socket wires as shown. Cut off the excess cable tie.



CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.
( ) Poor solder connections.
( ) Solder bridges between foil patterns.
( ) Protruding leads which could touch together.
( ) Transistors for the proper type and installation.
( ) Electrolytic and tantalum capacitors for the correct position of the plus (+) lead.
( ) Diodes for the correct position of the banded end.

( ) Set the circuit board and integrated circuits aside temporarily. The integrated circuits will be installed later. Also, save the leftover white wire and 8-wire cable for use later.

FINISH

DISPLAY CIRCUIT BOARD

PARTS LIST

Remove pack #2 (PK 2) from the box and check the parts against the following list and the Display Circuit Board Parts Pictorial (Illustration Booklet, Page 2).

RESISTORS

NOTE: The following resistors are 1/4-watt, 5% (gold fourth band), unless marked otherwise. The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check the resistors against the Parts List.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
A1	1-56-12	8	15 Ω (brown-green-black)	R208, R209, R210, R211, R212, R213, R214, R215
A1	1-61-12	4	180 Ω (brown-gray-brown)	R218, R219, R220, R227
A1	1-92-12	2	330 Ω (orange-orange-brown)	R216, R222
A1	1-66-12	7	560 Ω (green-blue-brown)	R201, R202, R203, R204, R205, R206, R207
A2	1-180	1	9100 Ω, 1/2-watt (white-brown-red)	R225
A1	1-80-12	1	10 kΩ (brown-black-orange)	R217
A2	1-127	1	91 kΩ, 1/2-watt (white-brown-orange)	R224
A2	1-176	1	910 kΩ, 1/2-watt (white-brown-yellow)	R223
A1	1-87-12	1	1 MΩ (brown-black-green)	R221

CAPACITORS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
B1	21-33	1	3.3 pF ceramic	C206
B1	21-84	1	24 pF ceramic	C207
B1	21-22	1	220 pF ceramic	C208
B1	21-140	2	.001 μF ceramic	C204, C205
B1	21-82	1	.02 μF ceramic	C203
B1	21-95	1	.1 μF ceramic	C202
B2	25-223	1	47 μF tantalum	C201

DIODES

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C1	56-61	1	GESTB-620	D203
C1	56-67	1	VR-10A	ZD204
C1	56-86	2	FD777	D201, D202

LIGHT-EMITTING DIODES (LED'S)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
C2	411-819	8	LED display	LED201, LED202, LED203, LED204, LED205, LED206, LED207, LED208
C3	412-616	1	LED lamp	LED209

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

TRANSISTORS — INTEGRATED CIRCUITS (IC's)

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number. (For integrated circuits, this refers only to the numbers; the letters may be different or missing.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

TRANSISTORS

D1	417-235	7	2N4121	Q201, Q202, Q203, Q204, Q205, Q206, Q207
D2	417-813	1	2N4959	Q219
D3	417-828	1	E-304 selected	Q218
D4	417-881	9	MPSA13	Q208, Q209, Q210, Q211, Q212, Q213, Q214, Q215, Q216
D4	417-885	1	MPSA65	Q220

Integrated Circuits

NOTES:

1. Some of the IC's may be packed in conductive foam. Do not remove the IC's from the foam until you are instructed to do so.
2. After you check the IC's, set them aside and keep them separate from the other parts. They will not be installed until your kit is nearly completed.

E1	443-712	1	MC14025	IC202
E2	443-711	1	74LS247	IC201
E2	443-713	1	MC14028	IC203

SOCKETS — CONNECTOR

F1	434-246	1	2-pin socket
F2	434-292	16	5-pin socket
F3	434-298	1	14-pin socket
F4	434-299	2	16-pin socket
F5	432-931	1	BNC connector with solder lug

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

HARDWARE

#4 Hardware

G1	250-52	2	4-40 × 1/4" screw
G2	254-9	2	#4 lockwasher

#6 Hardware

G3	250-70	1	6-32 × 3/16" flat head screw
G4	252-3	1	6-32 nut
G5	259-1	1	#6 solder lug
		5	LOCK WASH[illegible]

Other Hardware

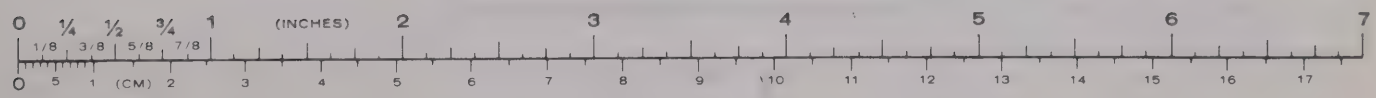
G6	252-198	1	3/8" nut
G7	253-30	1	1/2" flat washer
G8	255-726	1	5/8" spacer

MISCELLANEOUS

H1	253-62	4	Small fiber washer	
H1	253-15	1	Large fiber washer	
H2	63-1277	1	Rotary switch	SW203
H3	64-31	1	Pushbutton switch	SW201
	85-1822-1	1	Display circuit board	
H4	204-2285	1	Connector bracket	
H5	490-5	1	Nut starter	

PARTS FROM FINAL PACK (in bottom of shipping carton)

A1	1-80-12	1	10k, 1/4-watt, 5% (brown-black-orange) resistor	R226
J1	61-32	1	Toggle switch	SW202
G7	253-30	1	1/2" flat washer	
	343-12	4-1/2"	Coaxial cable	
D1	417-235	1	2N4121 transistor	Q217
J2	432-918	1	Right angle connector with hardware	
J3	432-930	1	BNC connector with hardware	
	340-2	6"	Bare wire	



STEP-BY-STEP ASSEMBLY

START

( ) Position the display circuit board as shown with the printed side (component side) up.

Install seven 560 Ω (green-blue-brown) resistors.
( ) R207
( ) R206
( ) R205
( ) R204
( ) R203
( ) R202
( ) R201

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) R218: 180 Ω (brown-gray-brown).

( ) R219: 180 Ω (brown-gray-brown).

( ) R222: 330 Ω (orange-orange-brown).

( ) R221: 1 MΩ **(brown-black-green).** Do not install a 15 Ω (brown-green-black) resistor here.

( ) R220: 180 Ω (brown-gray-brown).

( ) R223: 910 kΩ, **1/2-watt** (white-brown-yellow).

( ) R224: 91 kΩ, **1/2-watt** (white-brown-orange).

( ) R225: 9100 Ω, **1/2-watt** (white-brown-red).

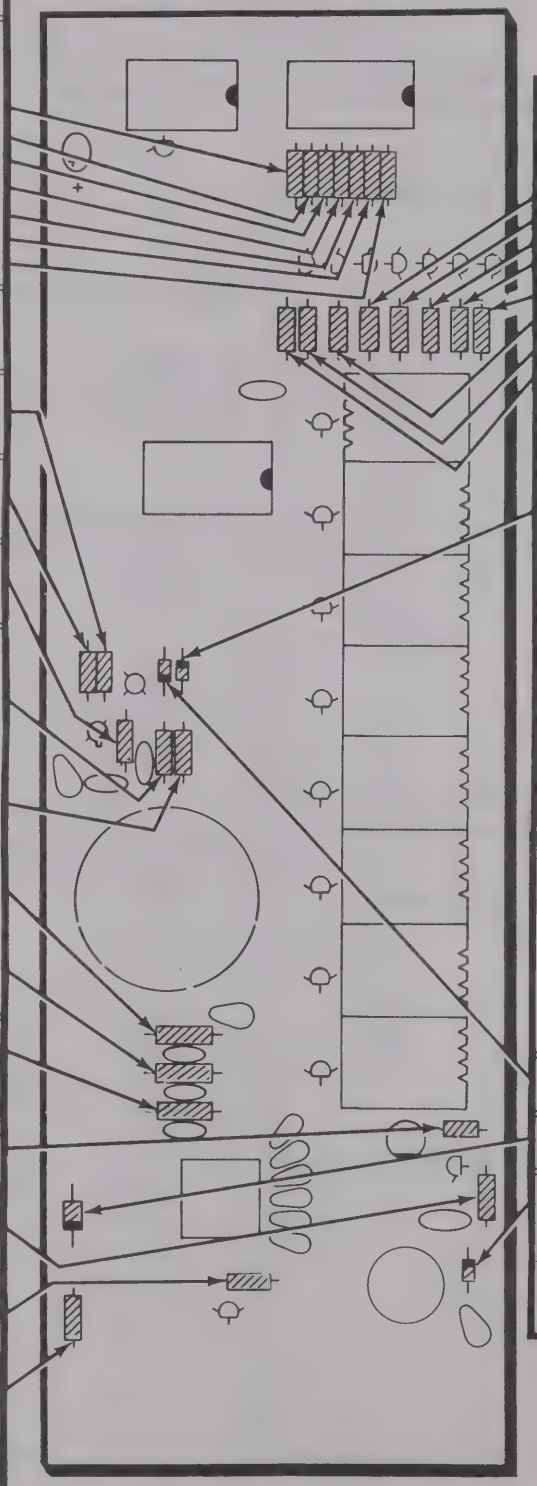
( ) R216: 330 Ω (orange-orange-brown).

( ) R217: 10 kΩ (brown-black-orange).

( ) R226 10 kΩ (brown-black-orange).

( ) R227: 180 Ω (brown-gray-brown).

( ) Solder the leads to the foil and cut off the excess lead lengths.



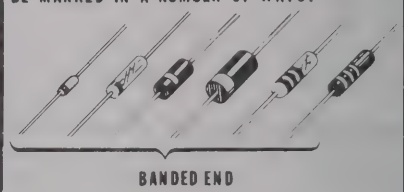
CONTINUE

Install eight 15 Ω (brown-green-black) resistors.
( ) R212.
( ) R211.
( ) R210.
( ) R209.
( ) R208.
( ) R213.
( ) R214.
( ) R215.

( ) Solder the leads to the foil and cut off the excess lead lengths.

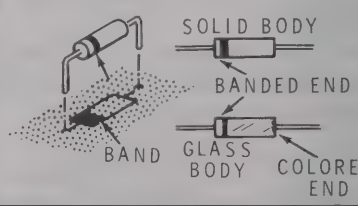
( ) D201: FD777 diode (#56-86).

IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.



BANDED END

CAUTION: ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



( ) D202: FD777 diode (#56-86).

( ) ZD204: VR-10A diode (#56-67).

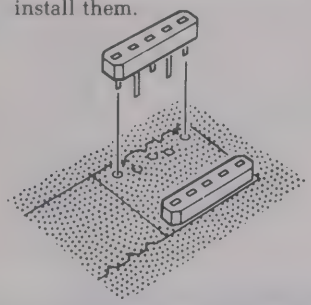
( ) D203: GETSB-620 diode (#56-61).

( ) Solder the leads to the foil and cut off the excess lead lengths.

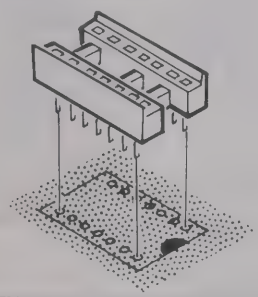
PICTORIAL 2-1

START

( ) Mount sixteen 5-pin sockets as shown. Solder the pins as you install them.



( ) 16-pin IC socket. Be sure the leads are straight, insert them into the holes, and solder the leads to the foil.



NOTE: Before you install ceramic capacitors, use long-nose pliers to remove any excess insulation from the capacitor leads.

REMOVE COATING EVEN WITH BOTTOM OF CAPACITOR BODY.

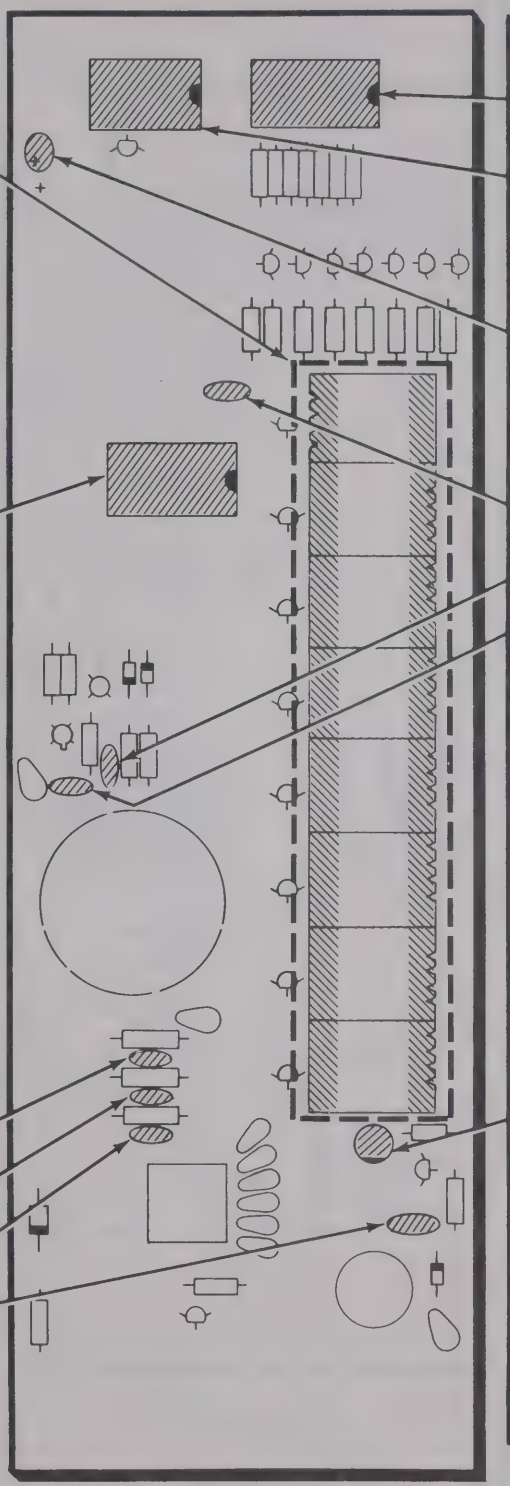
( ) C206: 3.3 pF ceramic.

( ) C207: 24 pF ceramic.

( ) C208: 220 pF ceramic.

( ) C203: .02 μF ceramic.

( ) Solder the leads to the foil and cut off the excess lead lengths.

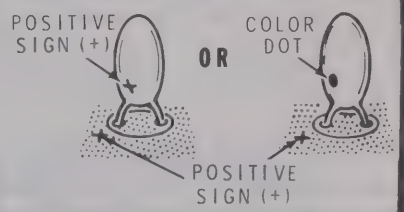


CONTINUE

( ) 16-pin IC socket. Solder the leads to the foil.

( ) 14-pin IC socket. Solder the leads to the foil.

( ) C201: 47 μF tantalum.



( ) C202: .1 μF ceramic.

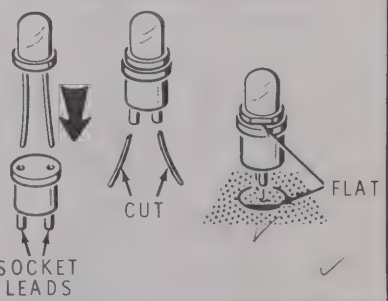
( ) C204: .001 μF ceramic.

( ) C205: .001 μF ceramic.

( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) LED 209:

1. Install the LED lamp into the 2-pin socket.
2. Cut off the excess lamp lead lengths.
3. Install the lamp and socket into the circuit board and solder only the **socket** leads to the foil. BE SURE the flat of the lamp is positioned as shown.



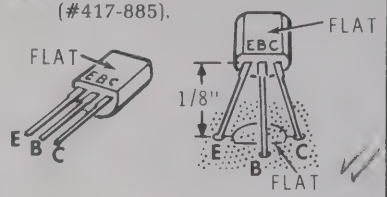
PICTORIAL 2-2

START

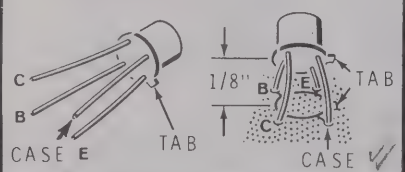
NOTE: When you install a transistor:

1. Refer to the illustration and identify the E, B, and C leads of the transistor.
2. Bend the center lead of the transistor as shown.
3. Insert the transistor leads into the corresponding E, B, and C holes in the circuit board.
4. Position the transistor 1/8" above the circuit board.
5. Turn the circuit board over, solder the leads to the foil, and cut off the excess lead lengths.

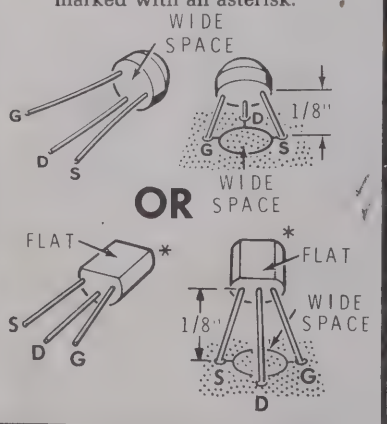
( ) Q220: MPSA65 transistor (#417-885).

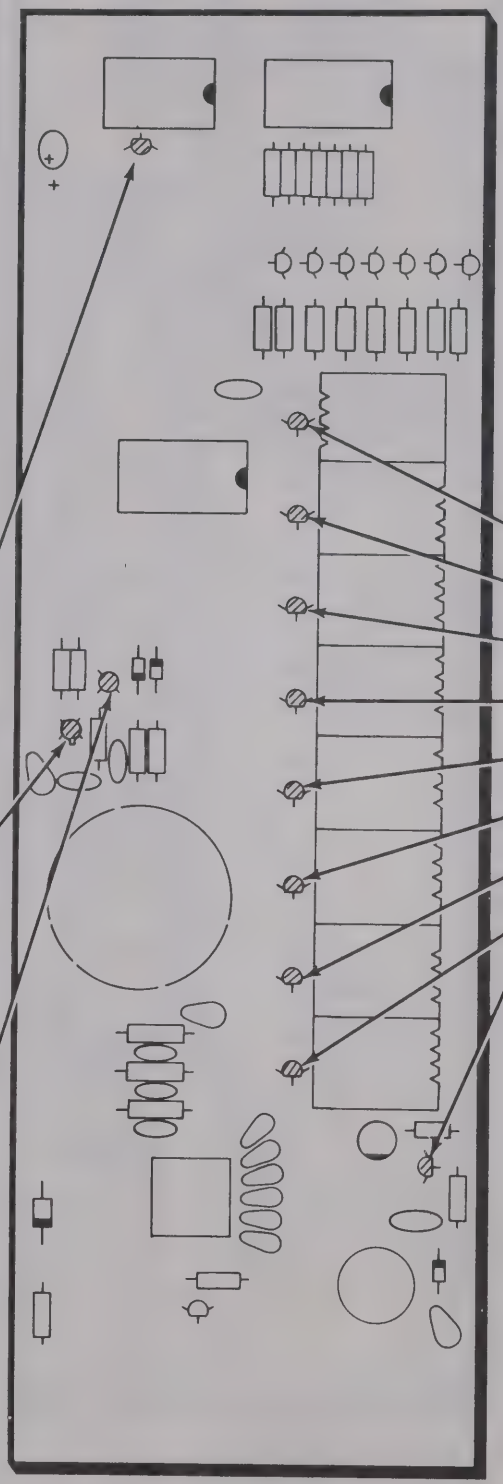


( ) Q219: 2N4959 transistor (#417-813).



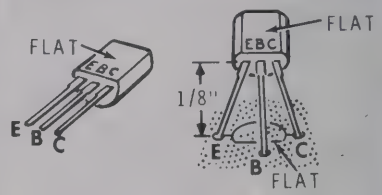
( ) Q218: E-304 selected transistor (#417-828). Note the position of the wide space of the transistor marked with an asterisk.





CONTINUE

Install nine MPSA13 transistors (#417-881).

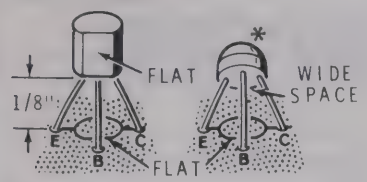


( ) Q208.
( ) Q209.
( ) Q210.
( ) Q211.
( ) Q212.
( ) Q213.
( ) Q214.
( ) Q215.
( ) Q216.

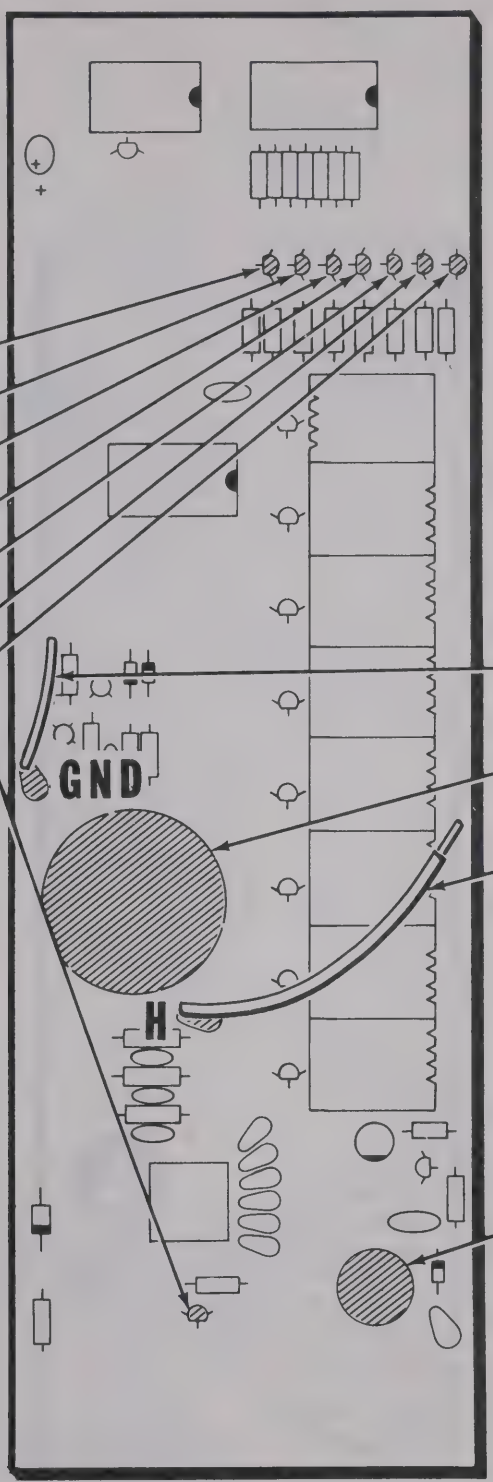
PICTORIAL 2-3

START

Install eight 2N4121 transistors (#417-235). Note the position of the wide space of the transistor marked with an asterisk.



( ) Q207 .....
( ) Q206 .....
( ) Q205 .....
( ) Q204 .....
( ) Q203 .....
( ) Q202 .....
( ) Q201 .....
( ) Q217 .....



PICTORIAL 2-4

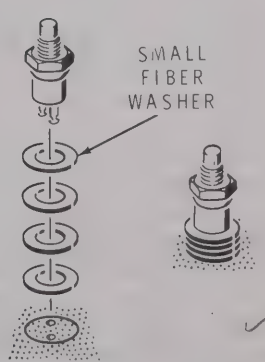
CONTINUE

( ) 3/4" bare wire at GND. Use white wire and remove its insulation. Solder the wire on **both** sides of the circuit board. The free end will be connected later.

( ) SW203: Rotary switch: Be sure it is seated properly on the board. Solder its lugs to the foil.

( ) 1-1/2" white wire at H. You will connect the free end later.

( ) SW201: Pushbutton switch. Tighten the nut on the switch and slide four small fiber washers onto the switch lugs. Then install the switch and solder its lugs to the foil. This may be a force fit.



START

( ) Turn the circuit board over as shown.

( ) Refer to Detail 2-5A (Illustration Booklet, Page 3) and prepare a 13" 8-wire cable as shown. (Save the cutoff lengths of wire for use later.) Use diagonal cutters or a knife to start separating the wires. See the inset drawing.

Connect the wires at end A of the prepared cable as follows. Insert the wires into the foil side of the circuit board. Then solder the wires on the **component** side and cut off the excess wire lengths as close to the board as possible. NOTE: The wire holes are labeled on the component side of the circuit board.

( ) Red to hole A.

( ) Orange to hole B.

( ) Yellow to hole C.

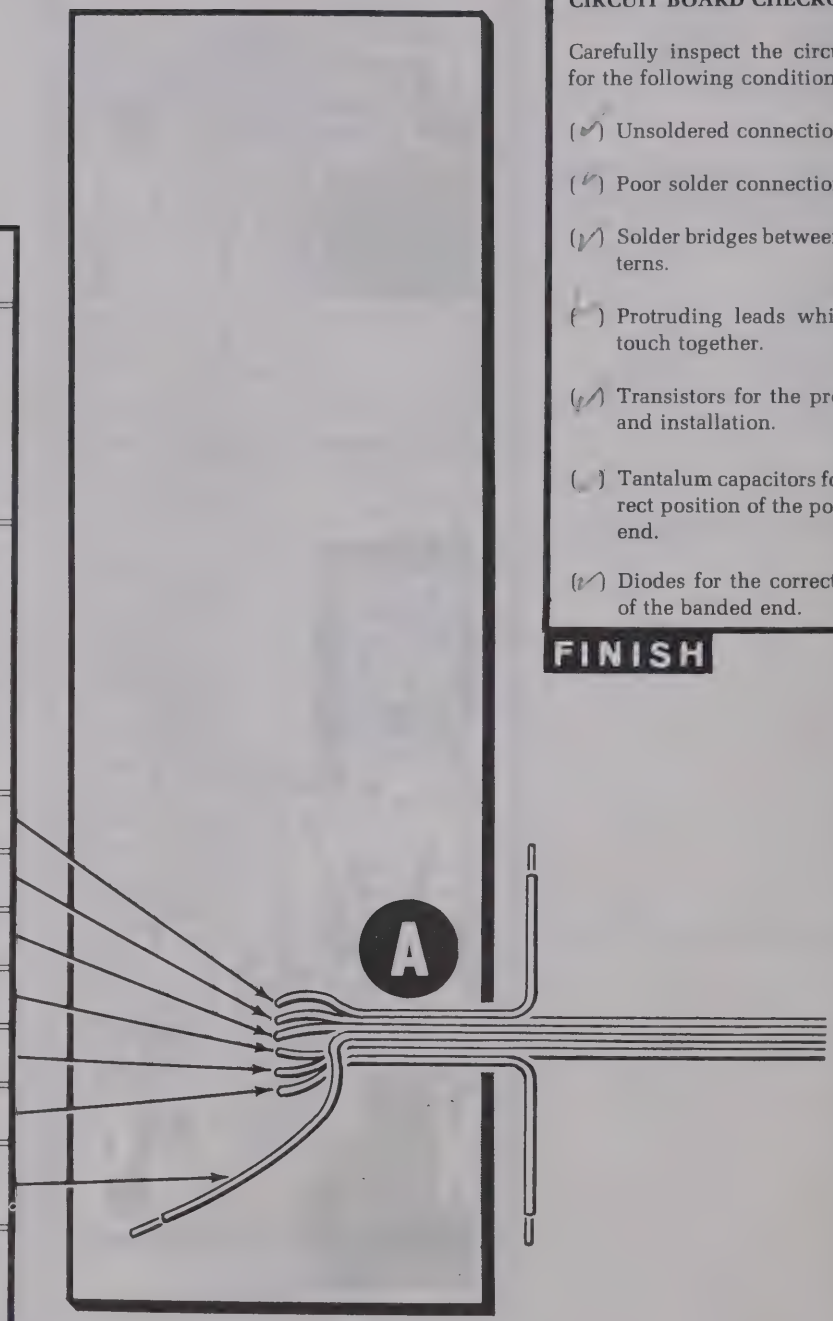
( ) Blue to hole D.

( ) Violet to hole E.

( ) Gray to hole F.

( ) Green. You will connect this wire later during "Initial Tests."

NOTE: You will install the integrated circuits and LED displays later. Keep these separate from the main circuit board integrated circuits.



PICTORIAL 2-5

CONTINUE

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

( ) Solder bridges between foil patterns.

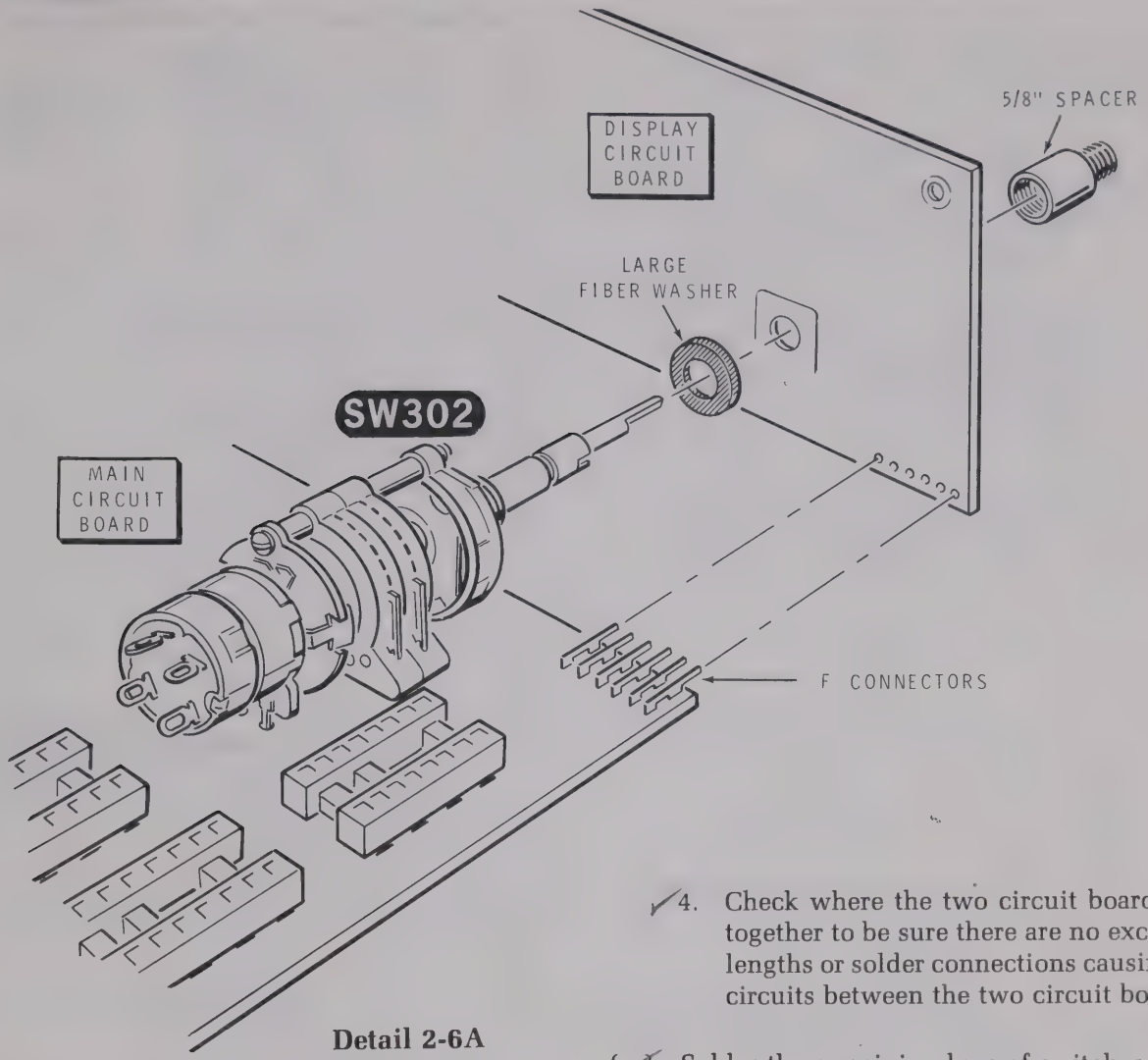
( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Tantalum capacitors for the correct position of the positive (+) end.

( ) Diodes for the correct position of the banded end.

FINISH



Detail 2-6A

Refer to Pictorial 2-6 (Illustration Booklet, Page 3) for the following steps.

( ) Position the main circuit board as shown.

( ) Refer to Detail 2-6A and slide a large fiber washer onto the shaft of switch SW302.

( ) Refer to Detail 2-6A and mount the display circuit board to the main circuit board:

1. Be sure the F connectors are straight; then insert them into the row of holes until the display circuit board sits snug against the main circuit board.

2. Install the 5/8" spacer on the shaft of switch SW302.

3. Be sure the display circuit board is properly positioned. Then solder the connectors to the component side of the display circuit board and **cut off the excess connector lengths.**

4. Check where the two circuit boards come together to be sure there are no excess lead lengths or solder connections causing short circuits between the two circuit boards.

( ) Solder the remaining lugs of switches SW301 and SW302 to the foil.

Connect some of the display circuit board cable wires to the main circuit board as follows. Plug the wire ends into the wire connectors. Do not solder the wires to the connectors.

( ) Gray to F.

( ) Red to A.

( ) Green to G.

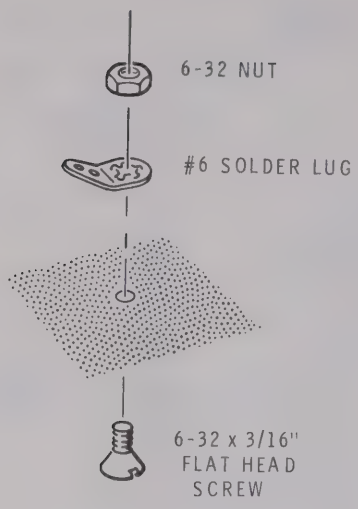
( ) Violet — will be connected later.

( ) Blue — will be connected later.

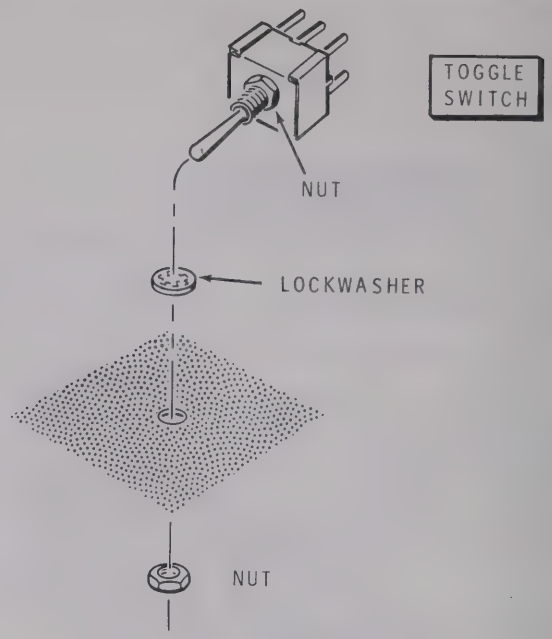
( ) Yellow to C.

( ) Orange to B.

( ) Set the circuit boards aside temporarily.



Detail 2-7A



Detail 2-7B

Refer to Pictorial 2-7 (Illustration Booklet, Page 4) for the following steps.

( ) Position the connector bracket as shown.

NOTE: Use the plastic nut starter supplied in this kit to hold and start 6-32 and 4-40 nuts on screws.

( ) Refer to Detail 2-7A and mount a #6 solder lug at AA. Use a 6-32 × 3/16" flat head screw and 6-32 nut. Be sure to position the solder lug as shown.

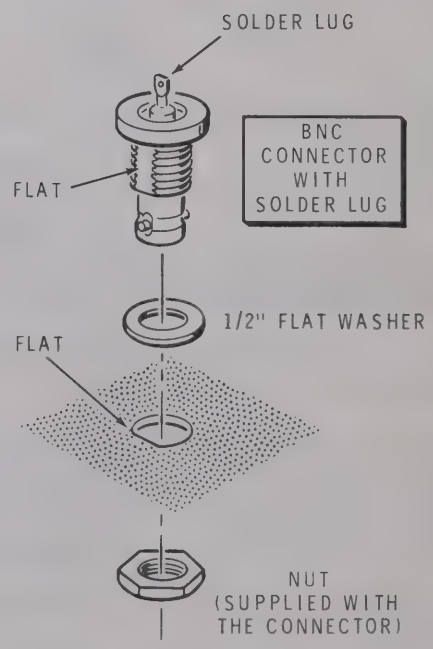
( ) Locate the toggle switch and remove the hardware, except for one nut. Be sure this nut is tight.

( ) SW202: Refer to Detail 2-7B and mount the toggle switch at SW202 (as shown in the Pictorial) with the supplied lockwasher and nut. Tighten this nut only finger tight. Discard the supplied flat washer.

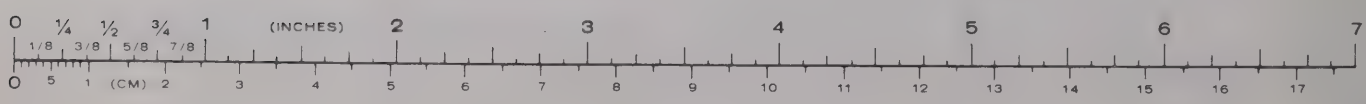
( ) Locate the BNC connector with solder lug (see Detail 2-7C). Discard the hardware supplied with the connector **except for the nut**.

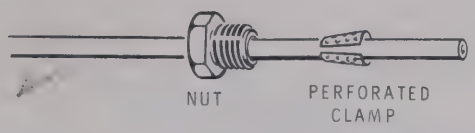
( ) Refer to Detail 2-7C and mount the connector at J1. Use a 1/2" flat washer and the supplied 1/2" nut as shown. Hold the connector with pliers to keep it from turning.

( ) Cut a 4-1/4" coaxial cable.

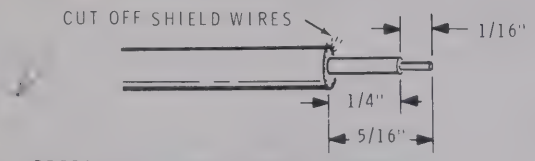


Detail 2-7C

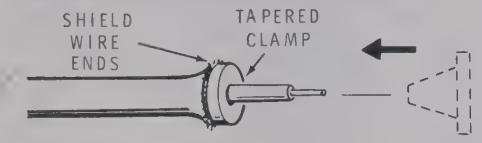




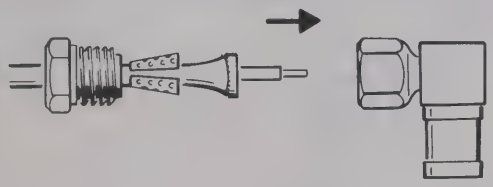
1. SLIDE THE NUT AND PERFORATED CLAMP ONTO ONE END OF THE CABLE AS SHOWN.



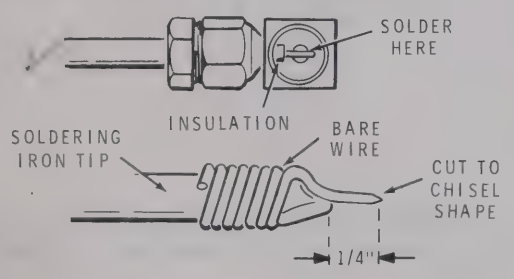
2. PREPARE THE CABLE END AS SHOWN.



3. SLIDE THE TAPERED CLAMP INTO POSITION BETWEEN THE SHIELD WIRES AND THE INSULATION OF THE INNER CONDUCTOR.



4. CAREFULLY PUSH THE CABLE INTO THE RIGHT ANGLE CONNECTOR, SLIDE THE PERFORATED CLAMP INTO PLACE, AND TIGHTEN THE NUT.



5. CAREFULLY SOLDER THE INNER CONDUCTOR TO THE CONNECTOR PIN. BE SURE THE CONDUCTOR IS IN THE PIN SLOT.

NOTE: IF YOU DO NOT HAVE A SMALL TIP SOLDERING IRON, PROCEED AS FOLLOWS: BE SURE YOUR SOLDERING IRON IS COOL. WRAP THE BARE WIRE (SUPPLIED) TIGHTLY AROUND THE SOLDERING IRON TIP AS SHOWN. ALLOW APPROXIMATELY 1/4" OF WIRE TO EXTEND BEYOND THE END OF THE SOLDERING IRON. CUT THE WIRE END TO A CHISEL SHAPE AS SHOWN. APPLY SOLDER TO THE TURNS OF BARE WIRE TO ACHIEVE A GOOD HEAT TRANSFER.

6. SOLDER THE CONNECTOR CAP INTO PLACE. DO NOT USE TOO MUCH HEAT. THE CONNECTOR ITSELF IS SOLDERED TOGETHER.

7. MAKE A CONTINUITY CHECK OF THE CABLE IF YOU HAVE AN OHMMETER.

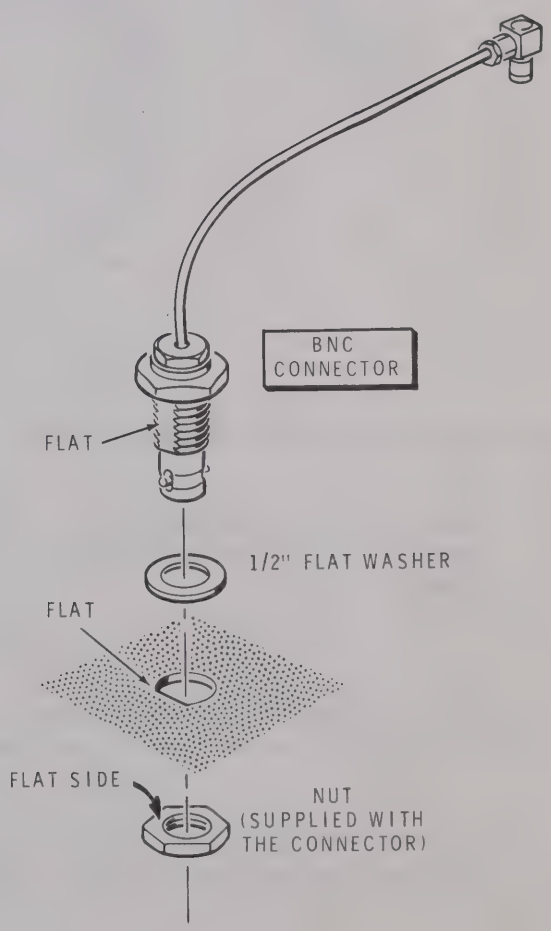
Detail 2-7D

( ) Refer to Detail 2-7D and install a right angle connector on one end of the cable as instructed there.

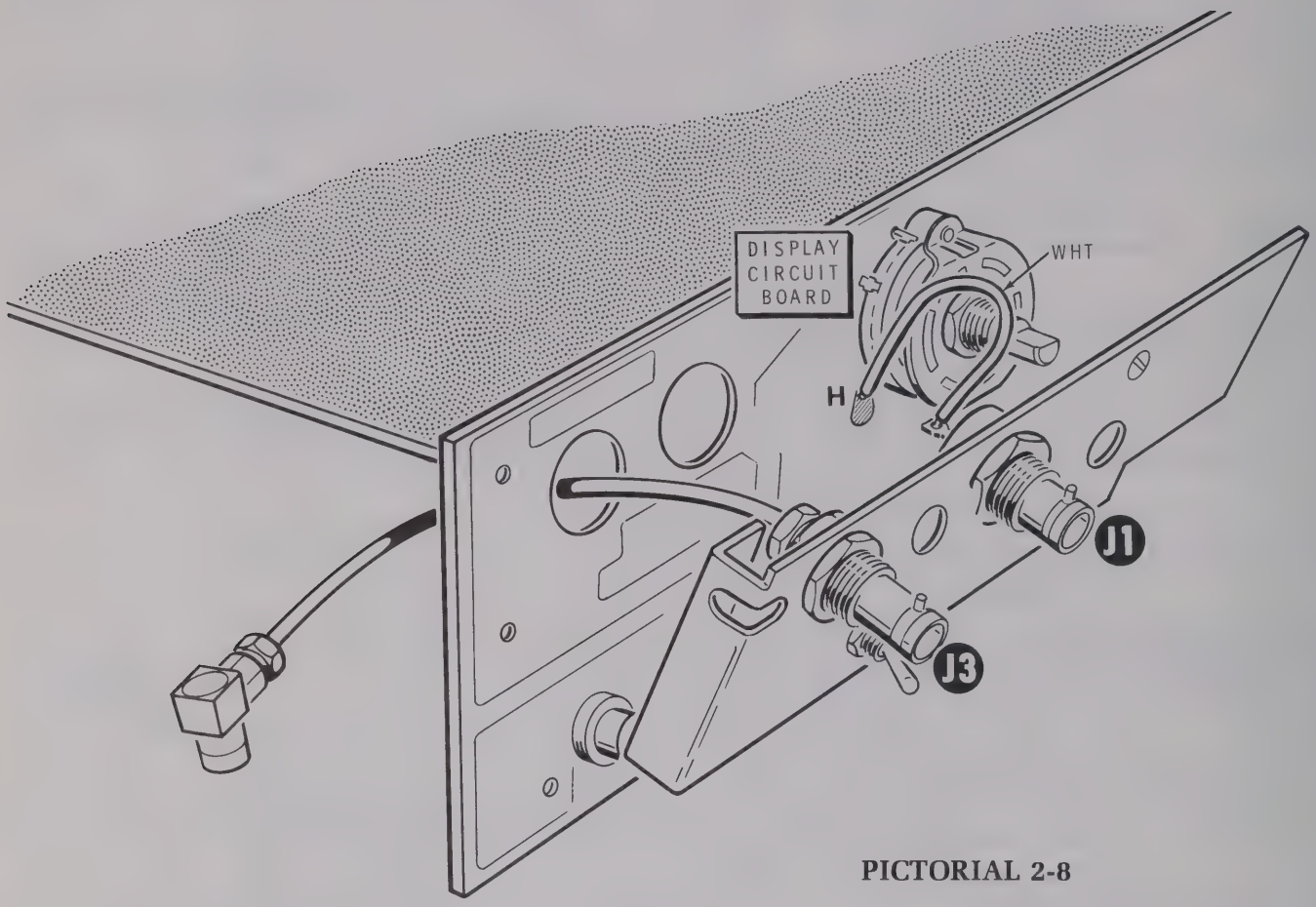
( ) Refer to Detail 2-7E (Illustration Booklet, Page 4) and install a BNC connector on the other end of the cable.

( ) Refer to Detail 2-7F and mount the BNC connector at J3. Use a 1/2" flat washer and the nut supplied with the connector. Hold the connector with pliers or a wrench to keep it from turning.

( ) If you installed a bare wire on your soldering iron tip, carefully remove and discard this wire. Be careful; it's hot!



Detail 2-7F

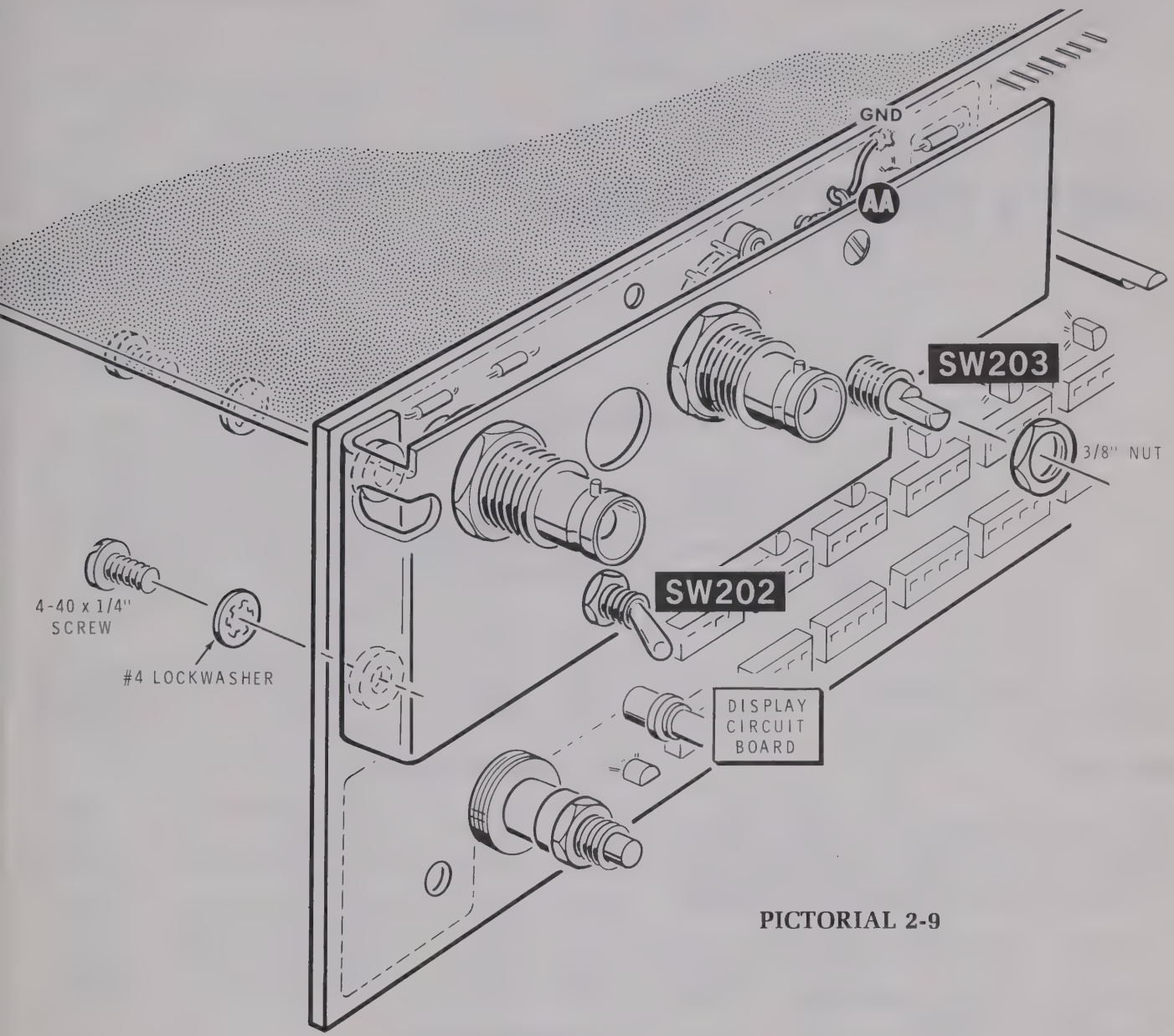


PICTORIAL 2-8

Refer to Pictorial 2-8 for the following steps.

( ) Route the cable coming from connector J3 through the proper display circuit board hole as shown.

( ) Connect the white wire coming from display circuit board hole H to connector J1. Solder the connection.



PICTORIAL 2-9

Refer to Pictorial 2-9 for the following steps.

( ) Position the connector bracket against the display circuit board. Be sure the lugs of toggle switch SW202 go into their holes.

( ) Secure the bracket with two 4-40 × 1/4" screws and two #4 lockwashers.

( ) Install a 3/8" nut on switch SW203.

( ) Tighten the nut on toggle switch SW202.

( ) Solder the lugs of toggle switch SW202 to the foil.

( ) Connect the bare wire coming from display circuit board hole GND to solder lug AA. Solder the connection.

( ) Set the circuit boards aside temporarily. Also set aside the IC's and displays, and keep them separate.

INPUT CIRCUIT BOARD

PARTS LIST

Remove pack #5 (PK 5) from the shipping carton and check the parts against the following list and the Input Circuit Board Parts Pictorial (Illustration Booklet, Page 5). You will assemble the parts from pack #3 later.

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
RESISTORS				
NOTE: The following resistors are 1/4-watt, 5% (gold fourth band) unless marked otherwise. The resistors may be packed in more than one envelope. Open all the resistor envelopes in this pack before you check the resistors against the Parts List.				
A1	1-125-12	3	22 Ω (red-red-black)	R105, R109, R112
A1	1-57-12	1	33 Ω (orange-orange-black)	R128
A1	1-107-12	3	82 Ω (gray-red-black)	R101, R121, R124
A1	1-60-12	5	100 Ω (brown-black-brown)	R102, R103, R108, R111, R118
A1	1-120-12	1	120 Ω (brown-red-brown)	R116
A1	1-103-12	3	150 Ω (brown-green-brown)	R122, R123, R125
A1	1-61-12	1	180 Ω (brown-gray-brown)	R119
A1	1-62-12	1	220 Ω (red-red-brown)	R120
A1	1-63-12	3	270 Ω (red-violet-brown)	R106, R110, R115
A1	1-64-12	1	390 Ω (orange-white-brown)	R129
Resistors (cont'd.)				
A1	1-65-12	1	470 Ω (yellow-violet-brown)	R127
A1	1-117-12	2	510 Ω (green-brown-brown)	R126, R130
A1	1-118-12	1	620 Ω (blue-red-brown)	R113
A1	1-70-12	1	1200 Ω (brown-red-red)	R107
A1	1-131-12	1	1600 Ω (brown-blue-red)	R114
A1	1-72-12	1	2200 Ω (red-red-red)	R104
CAPACITORS				
B1	21-157	1	5 pF ceramic	C101
B1	21-60	2	18 pF ceramic	C108, C111
B2	21-182	17	.047 μF (473) ceramic	C102, C103, C104, C105, C106, C107, C109, C110, C112, C113, C114, C116, C117, C118, C119, C120, C121
B3	25-220	2	10 μF tantalum	C115, C130

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.

CONTROL — COIL — DIODES

C1	10-940	1	200 Ω control	R117
C2	45-57	1	10 μH coil	L101
C3	56-67	1	VR-10A diode	ZD105
C3	56-87	2	FH1100 diode	D101, D102

TRANSISTORS — INTEGRATED CIRCUITS (IC's)

NOTE: Transistors and integrated circuits are marked for identification in one of the following four ways:

1. Part number.
2. Type number. (For integrated circuits this refers only to the numbers; the letters may be different or missing.)
3. Part number and type number.
4. Part number with a type number other than the one listed.

D1	417-839	4	2N5179 transistor	Q101, Q102, Q103, Q104
D2	443-714	1	11C01 IC	IC105
D2	443-715	1	11C70 IC	IC106

MISCELLANEOUS

	85-1823-1	1	Input circuit board
E1	432-134	4	Wire connector
E2	432-734	11	F connector
E3	432-916	1	Cable connector
E4	434-299	2	16-pin IC socket

Solder

STEP-BY-STEP ASSEMBLY

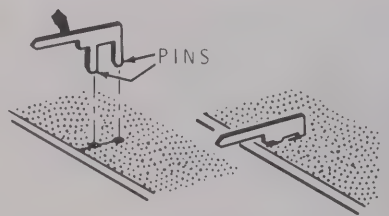
START

NOTES:

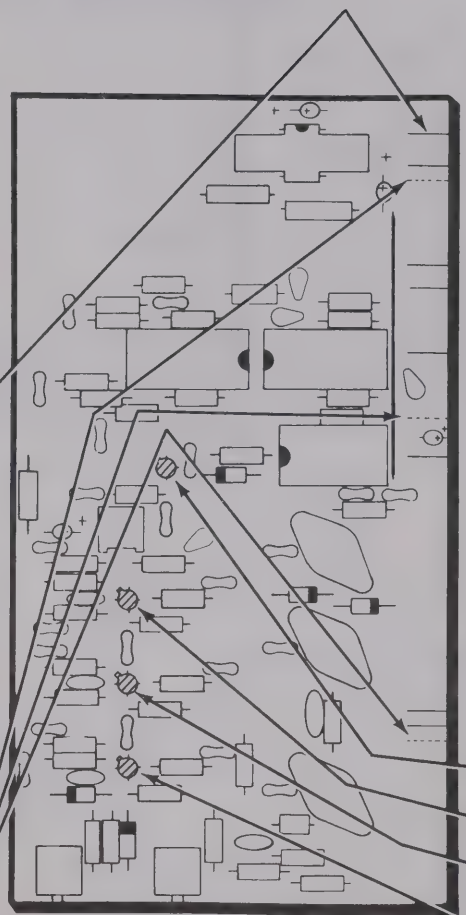
1. This kit is designed to operate at very high frequencies. Therefore, some of the foils on this circuit board are very small and close together. Be very careful when soldering that you do not use too much heat or cause a solder bridge.

2. Mount all parts as close to the circuit board as possible and cut off the excess lead lengths as close to the circuit board as possible.

( ) Install eleven F connectors — eight on the component side and three on the bottom side of the circuit board. First, insert the pins into the circuit board holes and press them in until the connector body rests against the circuit board. Then, on the bottom side of the board, solder the pins to the foil. Be sure each connector is against the circuit board.



Install these three connectors on the bottom of the board.



CONTINUE

Install each of the four 2N5179 transistors (#417-839) as follows:

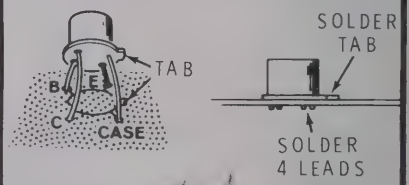
1. Refer to the illustration below and position the transistor so its tab is positioned over the tab on the circuit board.

2. Insert the transistor leads into the corresponding holes in the circuit board.

3. Position the transistor all the way down against the circuit board.

4. Solder the tab to the foil on the component side of the circuit board.

5. Turn the circuit board over, carefully solder all four leads to the foil, and cut off the excess lead lengths.



( ) Q104 .....

(✓) Q103 .....

( ) Q102 .....

(✓) Q101 .....

PICTORIAL 3-1

START

NOTE: Several of the following resistors have similar color codes. Be sure you install the correct resistor at each location.

( ) R126: 510 Ω (**green-brown**-brown).

( ) R125: 150 Ω (**brown-green**-brown).

( ) R124: 82 Ω (gray-red-black).

( ) R122: 150 Ω (**brown-green**-brown).

( ) R121: 82 Ω (gray-red-black).

( ) R120: 220 Ω (red-red-brown).

( ) R118: 100 Ω (brown-black-brown).

( ) R114: 1600 Ω (**brown-blue**-red).

( ) R113: 620 Ω (**blue-red**-brown).

( ) R112: 22 Ω (red-red-black).

( ) R109: 22 Ω (red-red-black).

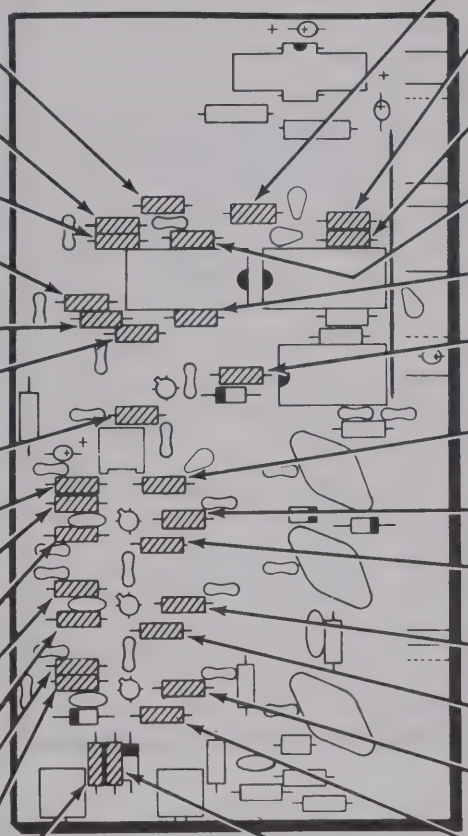
( ) R107: 1200 Ω (brown-red-red).

( ) R105: 22 Ω (red-red-black).

( ) R104: 2200 Ω (red-red-red).

( ) R101: 82 Ω (gray-red-black).

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) R128: 33 Ω (orange-orange-black).

( ) R130: 510 Ω (**green-brown**-brown).

( ) R129: 390 Ω (orange-white-brown).

( ) R127: 470 Ω (yellow-violet-brown).

( ) R123: 150 Ω (**brown-green**-brown).

( ) R119: 180 Ω (brown-gray-brown).

( ) R116: 120 Ω (brown-red-brown).

( ) R115: 270 Ω (red-violet-brown).

( ) R111: 100 Ω (brown-black-brown).

( ) R110: 270 Ω (red-violet-brown).

( ) R108: 100 Ω (brown-black-brown).

( ) R106: 270 Ω (red-violet-brown).

( ) R103: 100 Ω (brown-black-brown).

( ) R102: 100 Ω (brown-black-brown).

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-2

START

Install seventeen .047 μF (473) ceramic capacitors.

( ) C120 .....

( ) C119 .....

( ) C118 .....

( ) C116 .....

( ) C114 .....

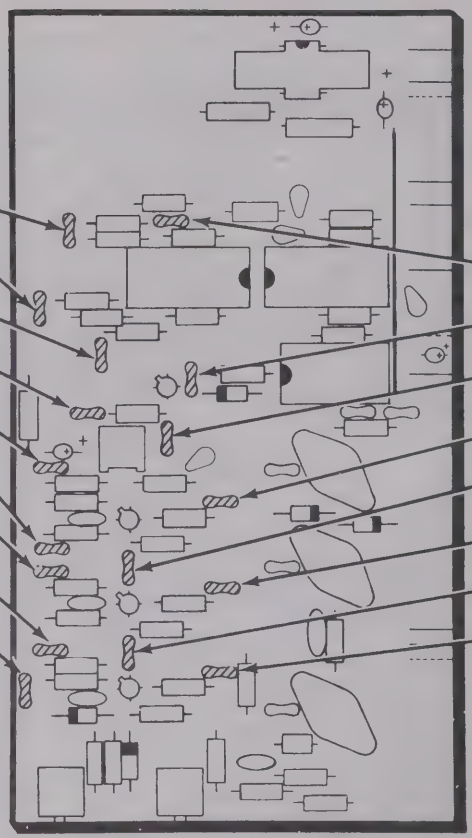
( ) C110 .....

( ) C109 .....

( ) C103 .....

( ) C102 .....

( ) Solder the leads to the foil and cut off the excess lead lengths.



CONTINUE

( ) C121.

( ) C105.

( ) C113.

( ) C117.

( ) C107.

( ) C112.

( ) C104.

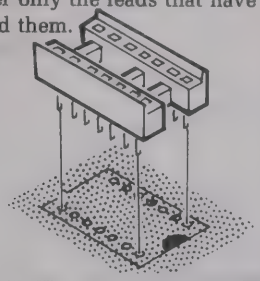
( ) C106.

( ) Solder the leads to the foil and cut off the excess lead lengths.

PICTORIAL 3-3

START

NOTE: When you install IC sockets in the following steps, be sure the leads are straight, insert them into the holes, and solder the leads to the foil. Solder only the leads that have foil around them.

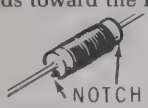


( ) 16-pin IC socket.

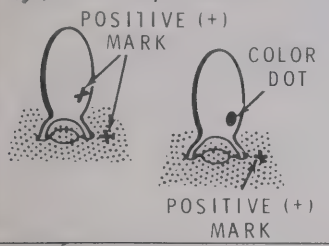
( ) 16-pin IC socket.

( ) R117: 200 Ω control. Solder the lugs to the foil.

( ) L101: 10 μH coil. Position the notches down as shown before you bend the leads. Bend the leads toward the notches.



( ) C115: 10 μF tantalum.



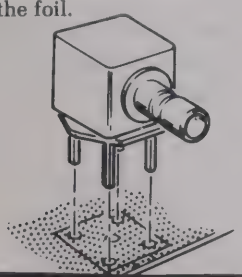
( ) C111: 18 pF ceramic. See Detail 3-4A.

( ) C108: 18 pF ceramic.

( ) C101: 5 pF ceramic.

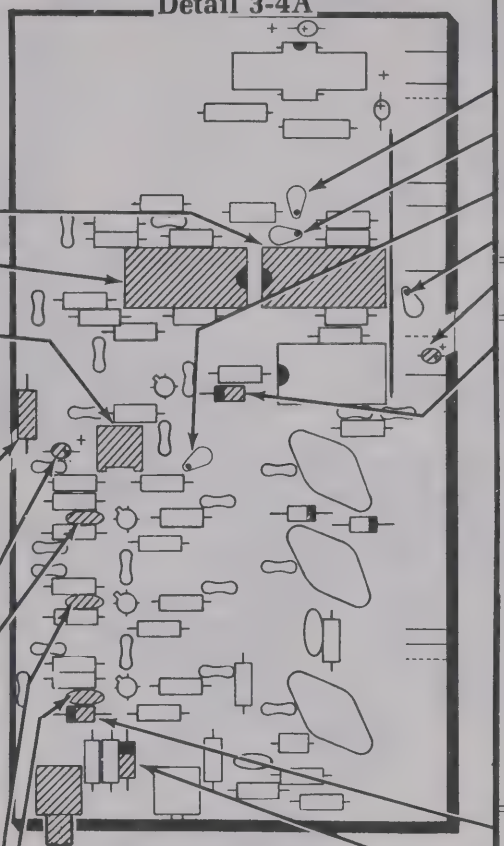
( ) Solder the leads to the foil and cut off the excess lead lengths.

( ) Cable connector. Solder the lugs to the foil.



NOTE: Before you install ceramic capacitors, use long-nose pliers to remove any excess insulation from the capacitor leads.

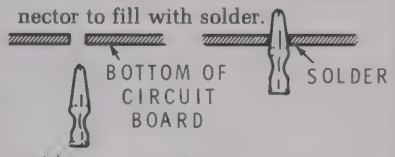
Detail 3-4A



PICTORIAL 3-4

CONTINUE

Install four wire connectors on the BOTTOM side of the circuit board. Solder each connector as you install it. Solder it on the bottom side of the circuit board. Do not allow the connector to fill with solder.



( ) C.

( ) B.

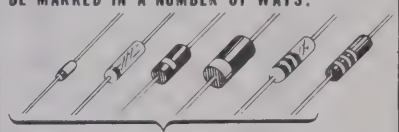
( ) A.

( ) D.

( ) C130: 10 μF tantalum.

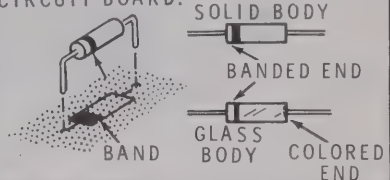
( ) ZD105: VR-10A diode (#56-67).

IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.



BANDED END

CAUTION: ALWAYS POSITION THE BANDED END AS SHOWN ON THE CIRCUIT BOARD.



( ) D102: FH1100 diode (#56-87).

( ) D101: FH1100 diode (#56-87).

( ) Solder the leads to the foil and cut off the excess lead lengths.

NOTE: The remaining circuit board component locations will not be used. Also, you will install the IC's later.

CIRCUIT BOARD CHECKOUT

Carefully inspect the circuit board for the following conditions.

( ) Unsoldered connections.

( ) Poor solder connections.

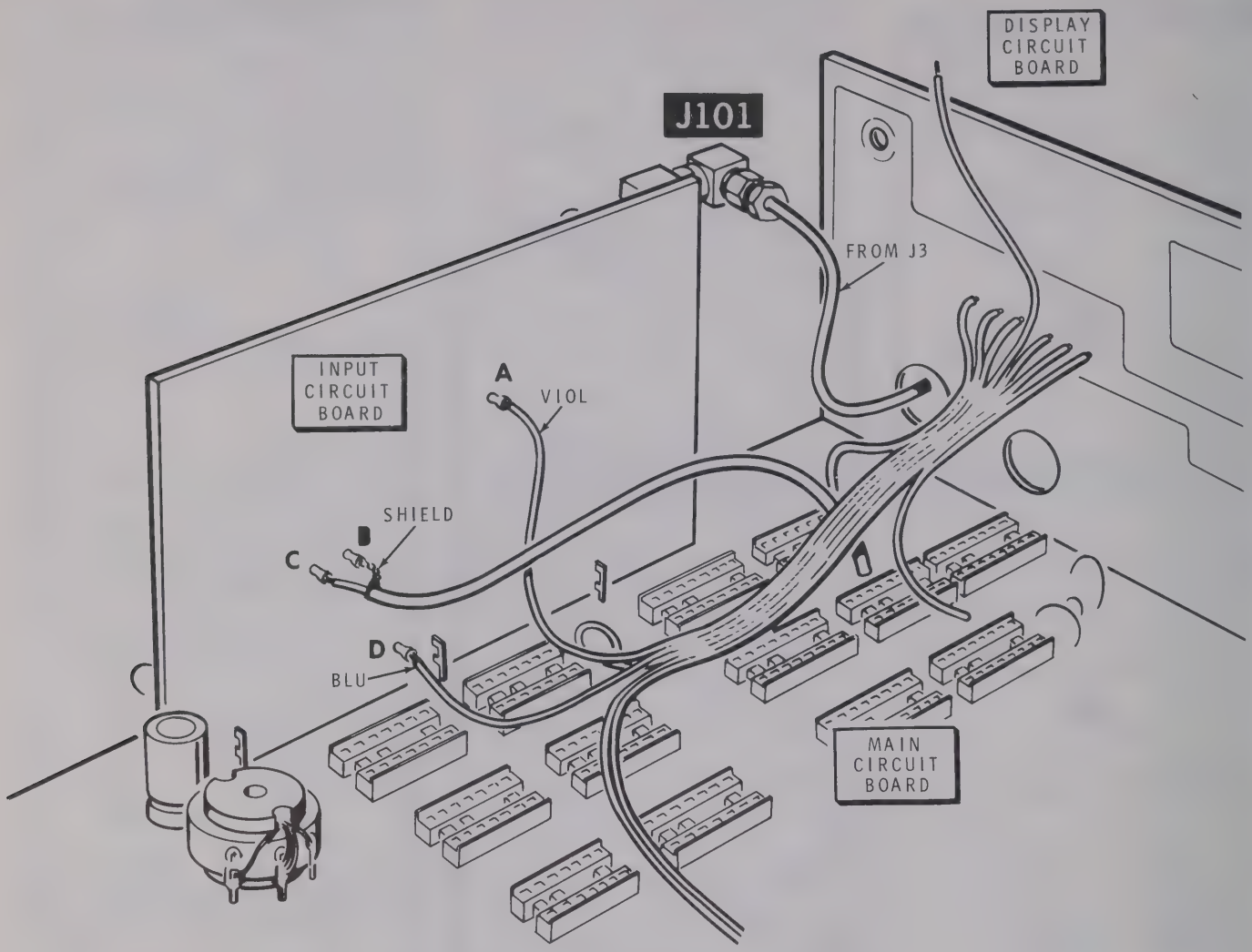
( ) Solder bridges between foil patterns.

( ) Protruding leads which could touch together.

( ) Transistors for the proper type and installation.

( ) Tantalum capacitors for the correct position of the positive (+) end.

( ) Diodes for the correct position of the banded end.



PICTORIAL 3-5

Refer to Pictorial 3-5 for the following steps.

( ) Position the main circuit board as shown.

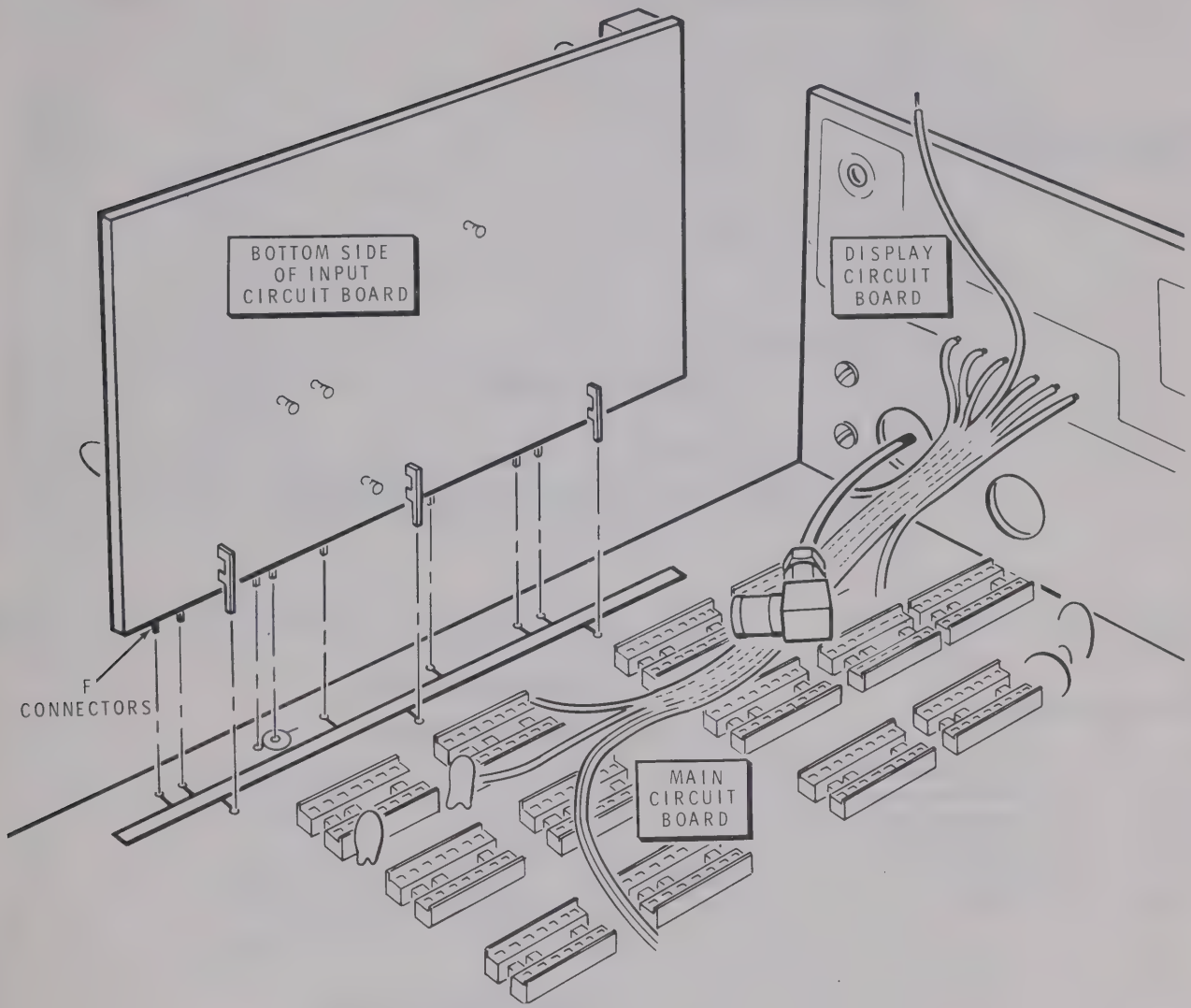
( ) Refer to Detail 3-5A and mount the input circuit board to ths main circuit board as follows:

1. Be sure the F connectors are straight; then insert them into the holes until the input circuit board sits snug against the main circuit board.
2. Be sure the input circuit board is properly positioned. Then solder the connectors to the bottom of the main circuit board and cut off the excess connector lengths.

Connect the remaining display circuit board cable wires to the input circuit board as follows: Plug the wire ends into the wire connectors.

( ) Blue to D.

( ) Violet to A.



Detail 3-5A

Connect the free end of the coaxial cable coming from the main circuit board to the input circuit board wire connectors:

( ) Inner lead to C.

( ) Shield lead to B.

( ) Push the connector on the cable coming from J3 onto connector J101 on the input circuit board.

( ) Set the circuit board assembly aside temporarily.

CHASSIS

PARTS LIST

Unpack pack #3 (PK 3), the remaining parts in the box, and check the parts against the following list and the Chassis Parts Pictorial (Illustration Booklet, Page 5).

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
ELECTRICAL PARTS				
A1	21-70	1	.01 µF ceramic capacitor	C1
A2	54-952	1	Power transformer	T1
A3	60-63	1	Slide switch with knob	SW3
A4	60-54	1	120/240 switch	SW1
A5	442-54	2	UA7805 IC	IC343, IC345
A5	442-630	1	MC7905 IC	IC344
HARDWARE				
#6 Hardware				
B1	250-1174	16	6-32 × 3/16″ black screw	
B2	250-1109	2	6-32 × 1/4″ black flat head screw	
B3	250-587	9	6-32 × 5/16″ screw	
B4	250-381	10	6-32 × 3/8″ black screw	
B5	250-106	6	6-32 × 3/8″ self-tapping screw	
B6	252-3	9	6-32 nut	
B7	252-80	4	6-32 cap nut	
B8	254-1	5	#6 internal tooth lock-washer	
B9	254-8	3	#6 split lockwasher	
B10	259-1	1	#6 solder lug	

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
Hardware (cont'd.)				
Other Hardware				
C1	250-593	2	#4 × 3/8″ self-tapping screw	
C2	252-7	1	3/8″ nut	
C3	252-197	3	1/2″ nut	
C4	253-30	1	1/2″ flat washer	
C5	258-707	2	Spring	
C6	259-27	1	3/8″ solder lug	
BUSHING — KNOBS				
D1	455-52	1	Round-shaft bushing	
D2	455-71	1	Small-shaft bushing	
D3	455-619	2	Large-shaft bushing	
D4	462-363	1	Red knob	
D5	462-951	1	Black knob	
D6	462-1001	1	Red and black knob with 1 white indicator	
D6	462-1014	1	Red and black knob with 2 white indicators	
CONNECTORS				
E1	432-76	1	Line cord connector	J6
E2	432-758	1	BNC connector with hardware	J4

MISCELLANEOUS

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
F1	75-139	1	IC insulator (between cardboard)	
	89-51	1	Line cord	
F2	90-1219-1	1	Cabinet top	
F3	200-1313-1	1	Chassis	
F4	203-1740-1	1	Back panel	
F5	204-2163	1	Back bracket	
F6	204-2304	1	L-bracket	
F7	205-1642-1	1	Back plate	
F8	205-1737	1	Support plate	
F9	210-86	1	Bezel	
F10	211-73	1	Handle	
F11	216-34	4	Plastic foot	
	266-932	2	Detent Parts	
			Consists of:	
G1	*214-195*	2	*Detent housing*	
G2	*266-869*	2	*Detent cover*	
G3	*266-870*	2	*Detent button*	
G4	*266-871*	2	*Detent bushing*	

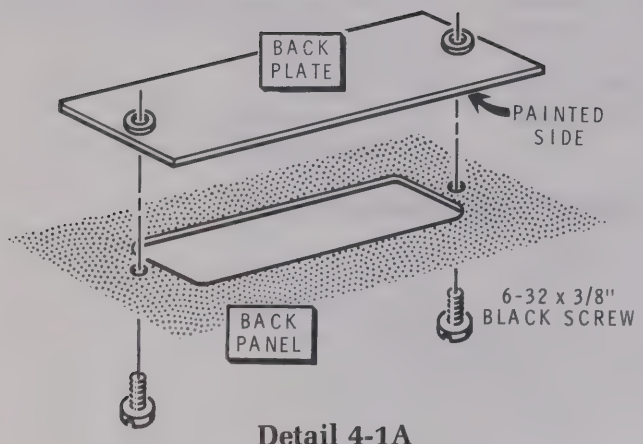
Miscellaneous (cont'd.)

KEY No.	HEATH Part No.	QTY.	DESCRIPTION	CIRCUIT Comp. No.
	343-15	10″	Coaxial cable	
	344-33	12″	Black wire	
G5	352-31	1	Thermal compound	
G6	391-605	2	Decorative insert	
G7	455-54	1	Nylon bushing	
G8	490-111	1	IC puller	
G9	73-34	1	Rubber insulator	
G10	260-16	2	Alligator clip	
G11	134-237	1	Cable assembly (with connector)	

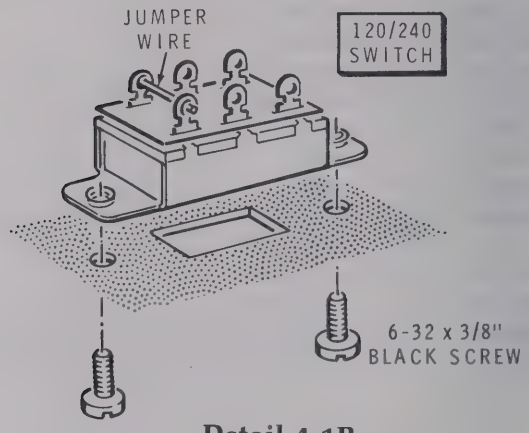
PARTS FROM FINAL PACK

C3	252-197	2	1/2″ nut
C4	253-30	2	1/2″ flat washer
H1	203-1812	1	Front panel

STEP-BY-STEP ASSEMBLY



Detail 4-1A



Detail 4-1B

Refer to Pictorial 4-1 (Illustration Booklet, Page 7) for the following steps.

( ) Place a soft cloth on your work surface to protect the back panel in the following steps.

( ) Place the back panel (printed side down) on your work surface as shown in the Pictorial.

( ) Refer to Detail 4-1A and mount the back plate to the back panel at BA. Be sure the painted side is as shown. Use two 6-32 × 3/8″ black screws.

( ) SW1: Refer to Detail 4-1B and mount the 120/240 switch at SW1. Use two 6-32 × 3/8″ black screws and be sure the switch lugs with the jumper wire are positioned as shown.

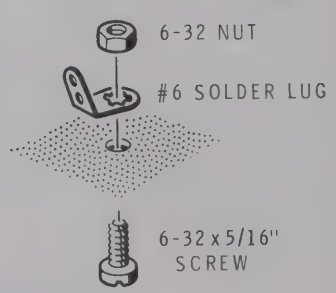
( ) Position switch SW1 to either "120" or "240" — whichever position matches the fuse you installed earlier.

( ) Position the back bracket as shown in the Pictorial.

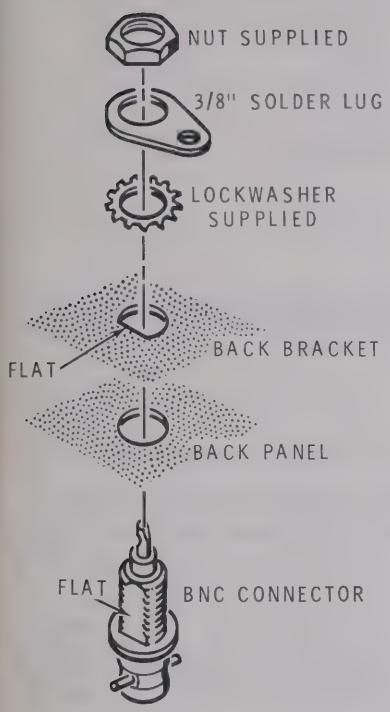
( ) Refer to Detail 4-1C and mount a #6 solder lug to the back bracket at BC. Use a 6-32 × 5/16″ screw and a 6-32 nut. Position the solder lug as shown.

NOTE: In the following steps, you will mount the back bracket to the back panel. Therefore, only loosely mount the next four parts. Then tighten all the hardware when you are instructed to do so.

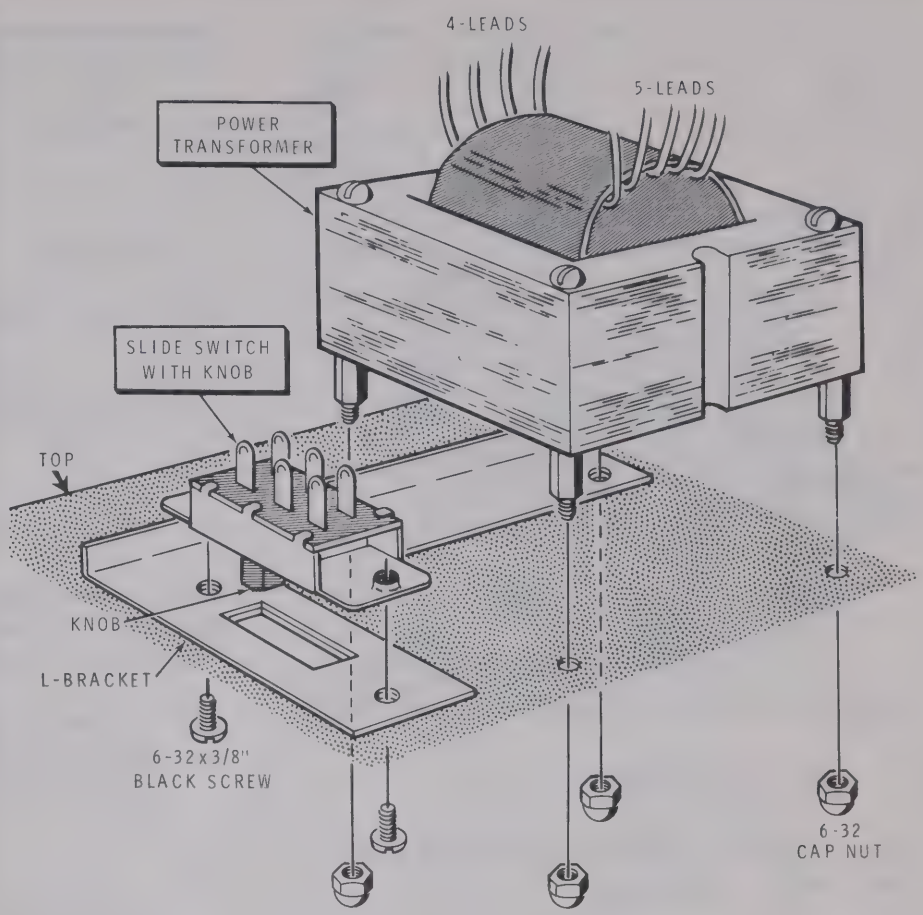
( ) J4: Refer to Detail 4-1D and mount the BNC connector at J4 (through the back panel and back bracket). Use the hardware supplied with the connector and the 3/8″ solder lug as shown.



Detail 4-1C



Detail 4-1D



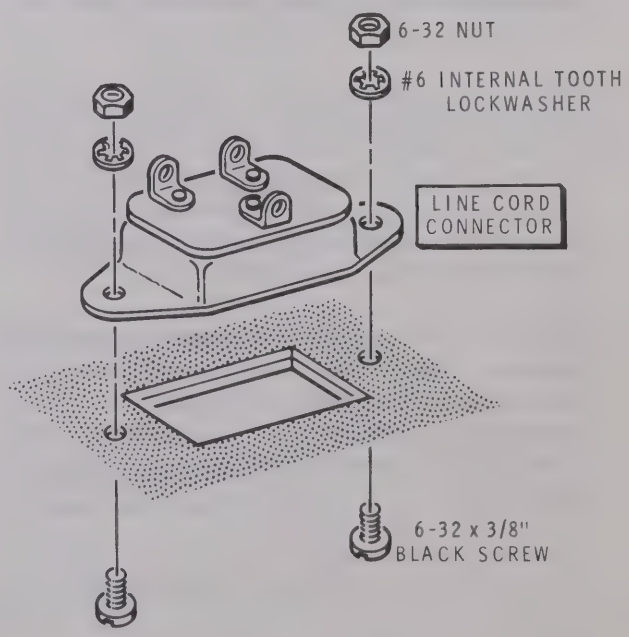
Detail 4-1E

( ) SW3: Refer to Detail 4-1E and mount the L-bracket and the slide switch with knob at SW3. Use two 6-32 × 3/8″ black screws. The switch is symmetrical; position it either way. Position the L-bracket as shown in the Pictorial.

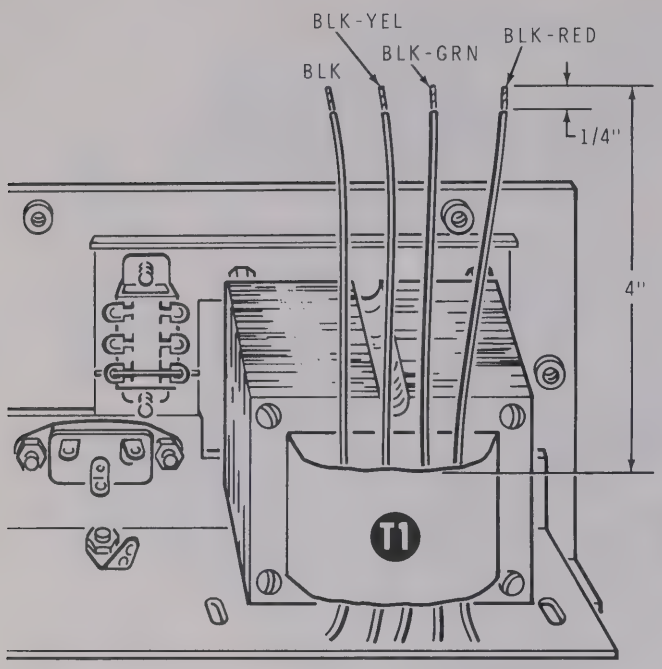
( ) T1: Refer to Detail 4-1E and mount the power transformer through the L-bracket holes and the back panel at T1. Use four 6-32 cap nuts. Be sure the leads come out of the transformer as shown in Pictorial 4-1.

( ) J6: Refer to Detail 4-1F and mount the line cord connector at J6. Use two 6-32 × 3/8″ black screws, two #6 internal tooth lockwashers, and two 6-32 nuts as shown. Be sure the center is positioned down as shown.

( ) Tighten the mounting hardware of the previous four parts you installed. Be sure the solder lug of connector J4 is bent up and positioned as shown in the Pictorial and switch SW3 operates freely.



Detail 4-1F



Detail 4-2A

Refer to Pictorial 4-2 (Illustration Booklet, Page 7) for the following steps.

( ) Refer to Detail 4-2A and cut the black, black-yellow, black-green, and black-red leads of transformer T1 to 4" and prepare the lead ends. Measure the leads from where they come out of the transformer.

NOTES:

1. In some of the following steps, you will be directed to "make a mechanically secure connection." To do this, insert the wire through and/or wrap it around the lug before you solder it. See the inset drawing on Pictorial 4-2.

2. In the following steps, (NS) means not to solder because other wires will be added later. "S-" with a number following it, such as (S-3) means to solder the connection. The number following the "S-" tells how many wires are at the connection.

Connect four transformer leads to switch SW1 as follows. Make mechanically secure connections.

( ) Black-yellow to lug 5 (S-1).

( ) Black-green to lug 2 (S-1).

( ) Black-red to lug 4 (NS).

( ) Black to lug 1 (NS).

( ) Prepare the following black wires:

5"
2"
3"

NOTE: As you connect wires and cables in the following steps, position and route them as shown in the Pictorials.

( ) Connect one end of the 5" black wire to switch SW1 lug 4 (NS). Make a mechanically secure connection. The free end will be connected later.

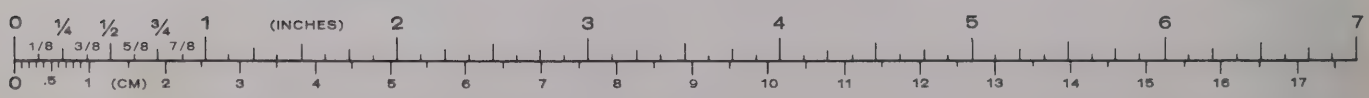
( ) Connect the 2" black wire coming from connector J6 lug 1 (S-1) to switch SW1 lug 1 (NS). Make mechanically secure connections.

( ) Connect one end of the 3" black wire to connector J6 lug 3 (S-1). Make a mechanically secure connection. The free end will be connected later.

( ) C1: Connect the .01 μF ceramic capacitor to switch SW1 between lugs 1 (S-3) and 4 (S-3). Make mechanically secure connections. Mount the capacitor so you can later bend it down when you put the cover on.

( ) Remove the insulation from 1" of black wire. Then cut off the 1" bare wire.

( ) Bend solder lug BC up near lug 2 of connector J6. Then connect the two lugs together with the bare wire and solder the connections. Make mechanically secure connections.



( ) If not already done, separate the remaining lengths of brown and red wires from the 8-wire cable and prepare the wires as follows:

LENGTH	WIRE
5"	red
5"	brown

Connect one end of the prepared wires to switch SW3 as follows. The free ends will be connected later.

( ) Red wire to lug 1 (S-1).

( ) Brown wire to lug 6 (S-1).

( ) Refer to Detail 4-2B and prepare a 1-5/8" coaxial cable as shown.

Connect end B of the prepared cable to switch SW3 as follows:

( ) Inner lead to lug 2 (S-1).

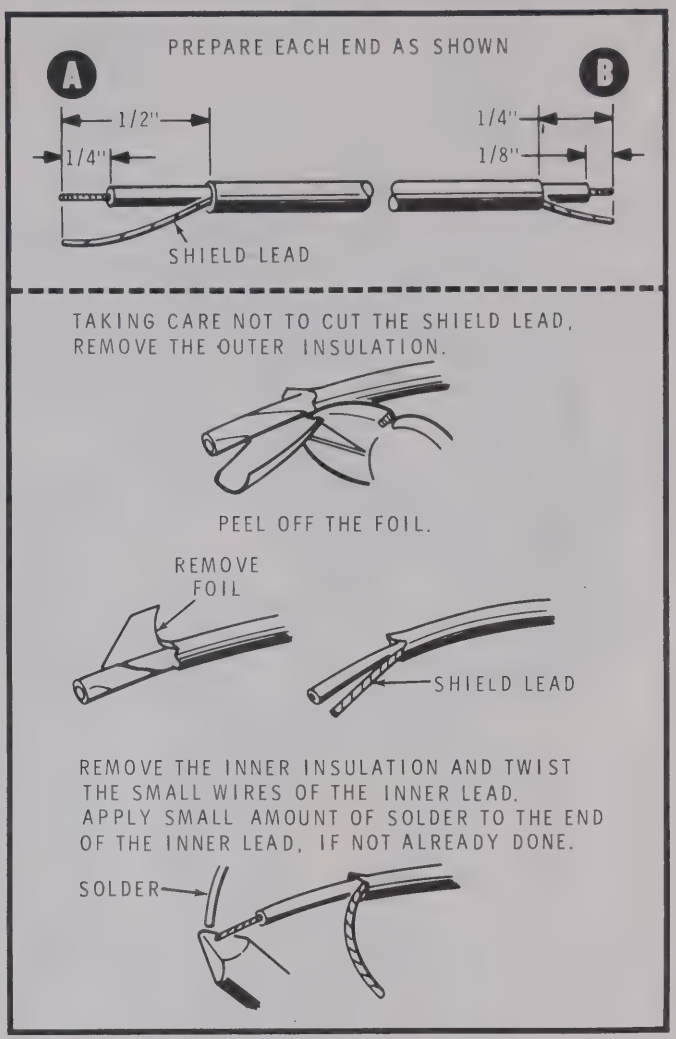
( ) Shield lead to lug 5 (NS).

Connect end A of the cable to connector J4:

( ) Inner lead to lug 1 (S-1).

( ) Shield lead to the solder lug (S-1). First bend the solder lug up.

( ) Refer to Detail 4-2C and prepare an 8" coaxial cable as shown.

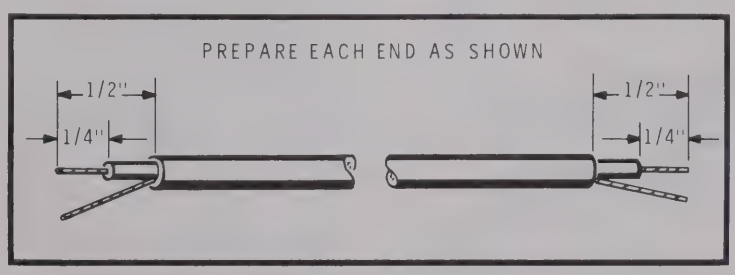

PREPARE EACH END AS SHOWN
A
B
1/2"
1/4"
1/4"
1/8"
SHIELD LEAD
TAKING CARE NOT TO CUT THE SHIELD LEAD, REMOVE THE OUTER INSULATION.
PEEL OFF THE FOIL.
REMOVE FOIL
SHIELD LEAD
REMOVE THE INNER INSULATION AND TWIST THE SMALL WIRES OF THE INNER LEAD. APPLY SMALL AMOUNT OF SOLDER TO THE END OF THE INNER LEAD, IF NOT ALREADY DONE.
SOLDER

Detail 4-2B

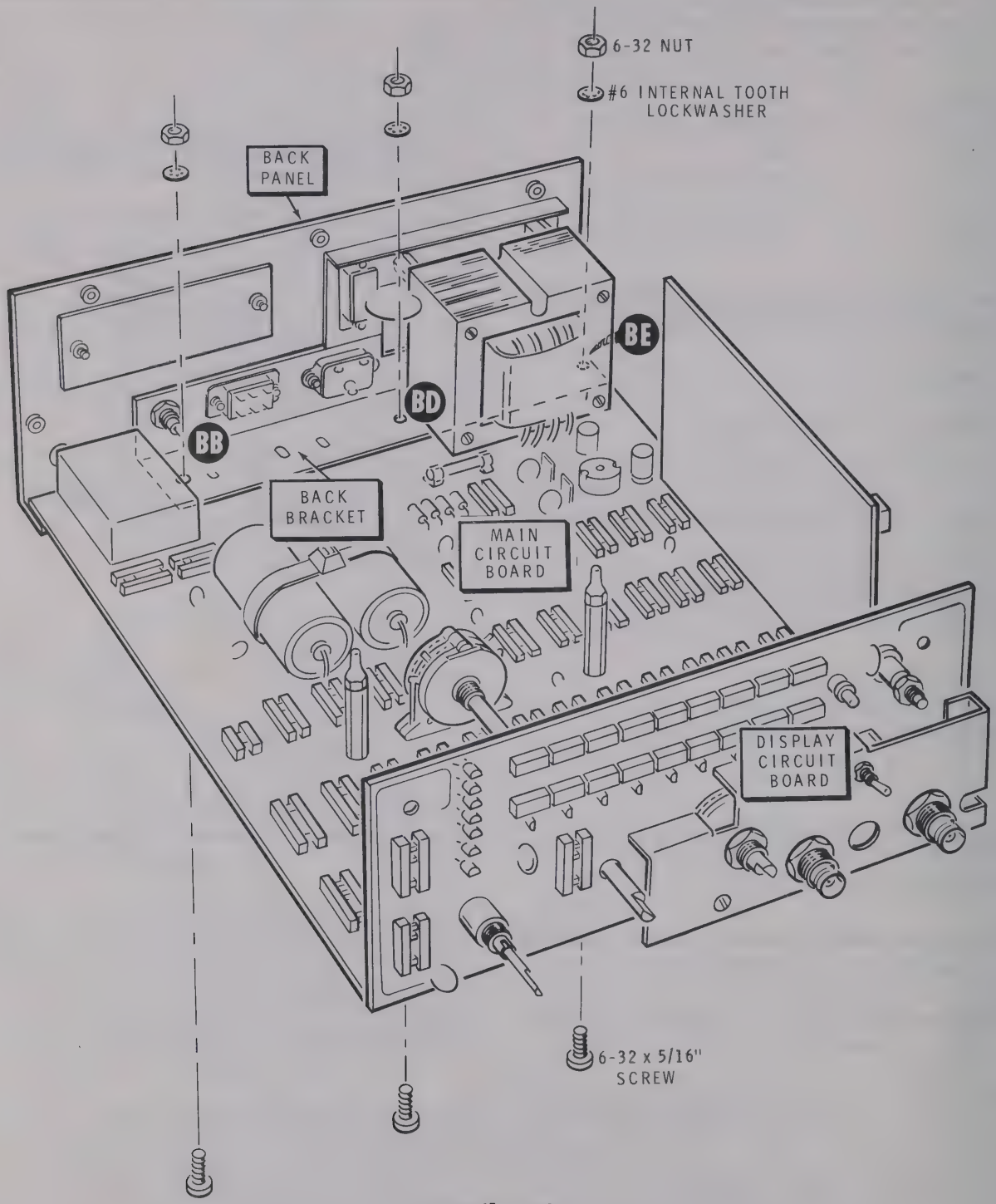
Connect either end of the prepared cable to switch SW3 as follows. The free end will be connected later.

( ) Inner lead to lug 3 (S-1).

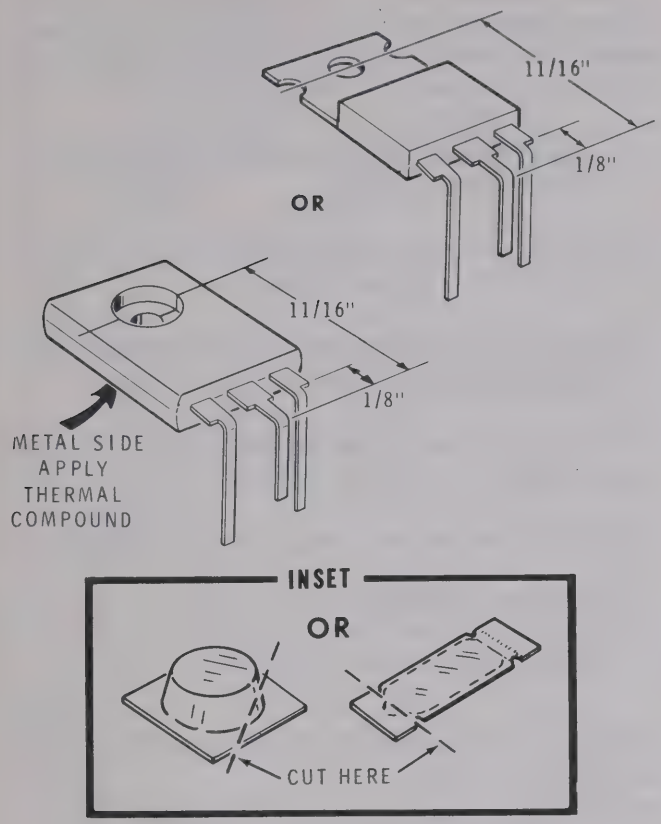
( ) Shield lead to lug 5 (S-2).



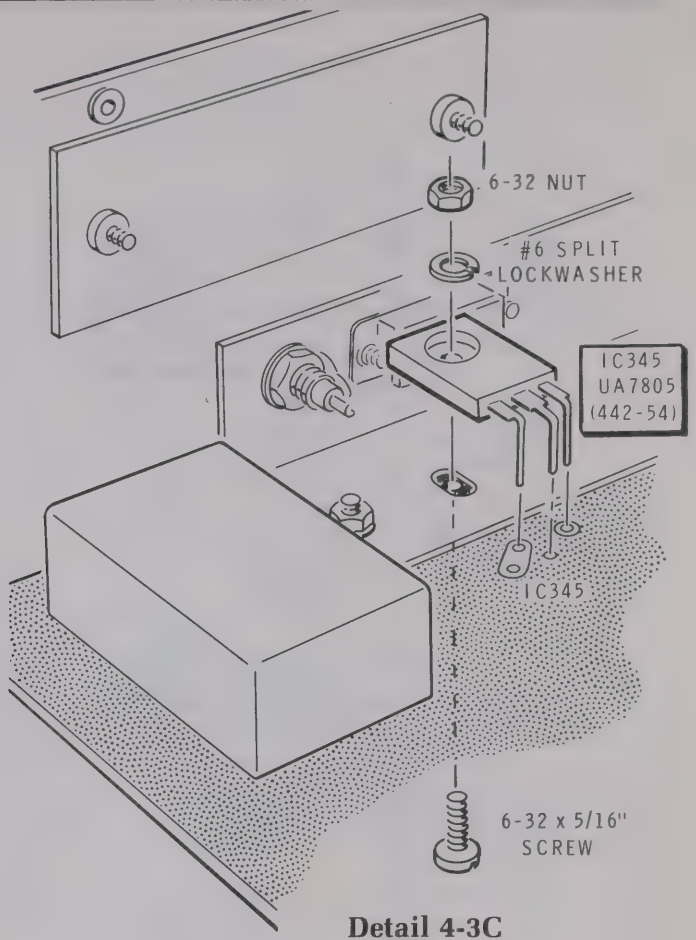
Detail 4-2C


6-32 NUT
#6 INTERNAL TOOTH LOCKWASHER
BACK PANEL
BE
BD
BB
BACK BRACKET
MAIN CIRCUIT BOARD
DISPLAY CIRCUIT BOARD
6-32 x 5/16" SCREW

Detail 4-3A



Detail 4-3B



Detail 4-3C

Refer to Pictorial 4-3 (Illustration Booklet, Page 7) for the following steps.

( ) Refer to Detail 4-3A and loosely mount the back bracket to the main circuit board as shown. Use three 6-32 × 5/16″ screws, #6 internal tooth lockwashers, and 6-32 nuts at BB, BD, and BE. Be sure you do not pinch any wires or cables between the metal parts and the circuit board.

( ) Position both ends of the inside surface of the back panel 10-9/16″ from the inside surface of the display circuit board as shown in the Pictorial. Make the measurements down close to the circuit board. Then tighten screws BB and BE. Recheck the dimensions and make any necessary adjustments. Then tighten screw BD.

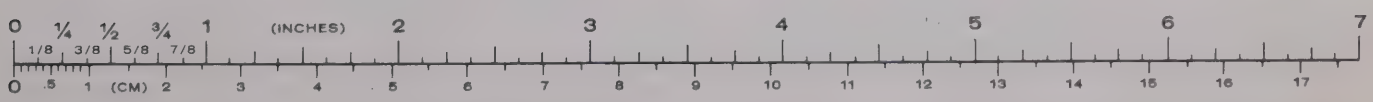
( ) Refer to Detail 4-3B, position the metal sides of the three IC's down, and then bend the leads as shown.

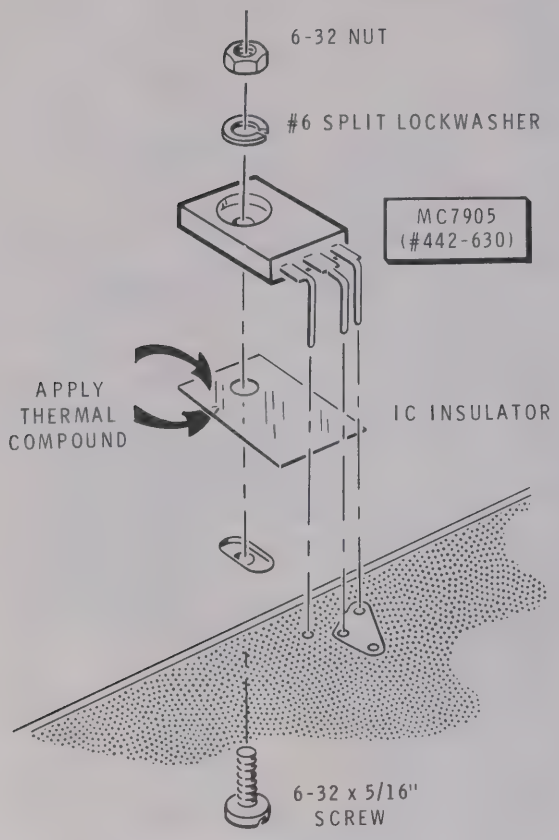
WARNING: You will be using Dow Corning 340 thermal heat sink compound in the next step and several other steps in the Manual. Although the compound is not caustic, it may cause temporary discomfort if it gets into your eyes. If this happens, rinse your eyes with warm water. If the compound gets into your clothing, the clothing may require professional cleaning. The compound contains Zinc Oxides, SiO_2, and slight traces of CO_2.

( ) Open the container of thermal compound and apply a thin layer of the compound to the metal side of all three IC's. See the inset drawing on Detail 4-3B.

( ) IC345: Refer to Detail 4-3C and mount a UA7805 IC (#442-54) at IC345. Use a 6-32 × 5/16″ screw, #6 split lockwasher, and 6-32 nut. Solder the leads to the foil and cut off the excess lead lengths.

( ) IC343: In a similar manner, mount another UA7805 IC at (#442-54) at IC343.





Detail 4-3D

( ) IC344: Refer to Detail 4-3D and mount the MC7905 IC (#442-630) at IC344 as follows:

1. Apply a thin layer of thermal compound to both sides of the IC insulator.

2. Mount the IC and its insulator at IC344 as shown. Use a 6-32 × 5/16″ screw, split lockwasher, and 6-32 nut; be sure the insulator is properly positioned under the IC.

3. Solder the leads to the foil and cut off the excess lead lengths.

Connect the free ends of the remaining wires and cable to the main circuit board as follows. Solder each connection as you install the wire and route the wires and cable as shown in the Pictorial.

( ) Black wire coming from switch SW1 lug 4 to hole L2 (S-1).

( ) Black wire coming from connector J6 lug 3 to hole L1 (S-1).

( ) Brown wire coming from switch SW3 lug 6 to hole P (S-1).

( ) Red wire coming from switch SW3 lug 1 to hole N (S-1).

( ) Cable coming from switch SW3 lugs 3 and 5:

- Inner lead to hole M (S-1).
- Shield lead to hole K (S-1).

Connect the remaining transformer leads to the main circuit board as follows:

( ) Either green to either hole GRN (S-1).

( ) Green-yellow to hole GRN/YEL (S-1).

( ) Remaining green to the remaining hole GRN (S-1).

( ) Either red to either hole RED (S-1).

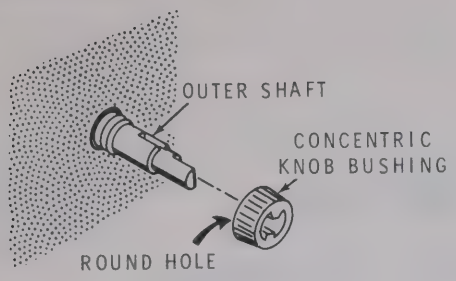
( ) Remaining red to the remaining hole RED (S-1).

Refer to Pictorial 4-4 (Illustration Booklet, Page 8) for the following steps.

NOTE: In the following steps, you will temporarily install the front panel and knobs. When you install a knob insert or a knob, support the rear of the switch by carefully pushing on it.

( ) Position the front panel in place as shown in the Pictorial.

( ) Place toggle switch SW202 in the 1 MΩ 110 MHz position.



Detail 4-4A

( ) Refer to Detail 4-4A and slide a round shaft bushing onto the shaft of switch SW302 as shown.

( ) Turn this switch to its full counterclockwise position.

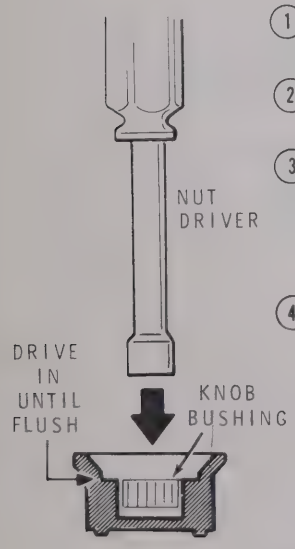
( ) Refer to Detail 4-4B and install a black knob on switch SW302. Line up the pointer with the EVENTS OP mark.

( ) Turn this switch to the FREQUENCY position.

( ) Refer to Detail 4-4C and push a small-shaft bushing onto the shaft of SW2/R326.

( ) Turn this control fully counterclockwise until it clicks (if not already done).

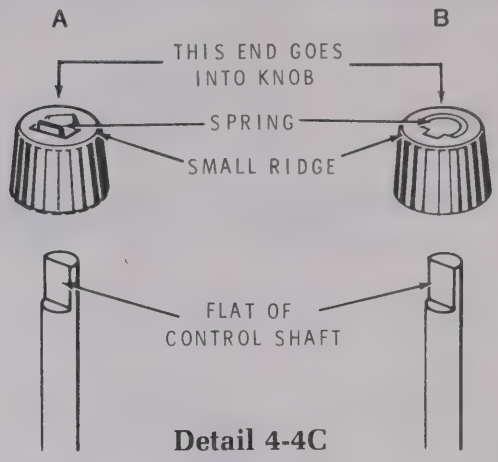
( ) As before, install a red knob on this shaft bushing. Line up the pointer with the POWER OFF mark.



1. LINE UP THE POINTER AS CALLED OUT IN THE STEP.
2. PUSH THE KNOB PART ONTO THE BUSHING.
3. NOW CAREFULLY REMOVE BOTH THE BUSHING AND THE KNOB. DO NOT ALLOW THE KNOB TO COME OFF THE BUSHING.
4. PLACE THE KNOB ON A TABLE OR OTHER FIRM SURFACE. PLACE A SOFT CLOTH UNDER THE KNOB TO PREVENT IT FROM BEING MARRED. THEN USE A NUTDRIVER OR A LARGE SCREWDRIVER AND DRIVE THE BUSHING INTO THE KNOB AS SHOWN. DO NOT DRIVE IT IN TOO FAR.
5. REPLACE THE KNOB ON THE CONTROL FROM WHICH IT WAS REMOVED.

Detail 4-4B

NOTE: THE KNOB BUSHING MAY LOOK LIKE EITHER A OR B BELOW. IT MUST GO ON THE SHAFT AS SHOWN.



Detail 4-4C

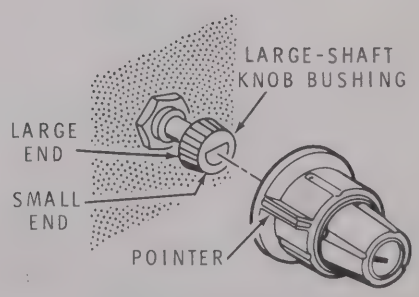
NOTE: Refer to Detail 4-4D and notice that the knob bushing is tapered. Be sure, in the next step, to place this bushing on the shaft with the small end facing out, or the knob will not slide onto it. If you are not sure which is the small end, roll the bushing on a flat surface; it will gradually turn toward the small end.

( ) Refer to Detail 4-4D and push the large ends of the large-shaft bushings onto switch shafts SW301 and SW203.

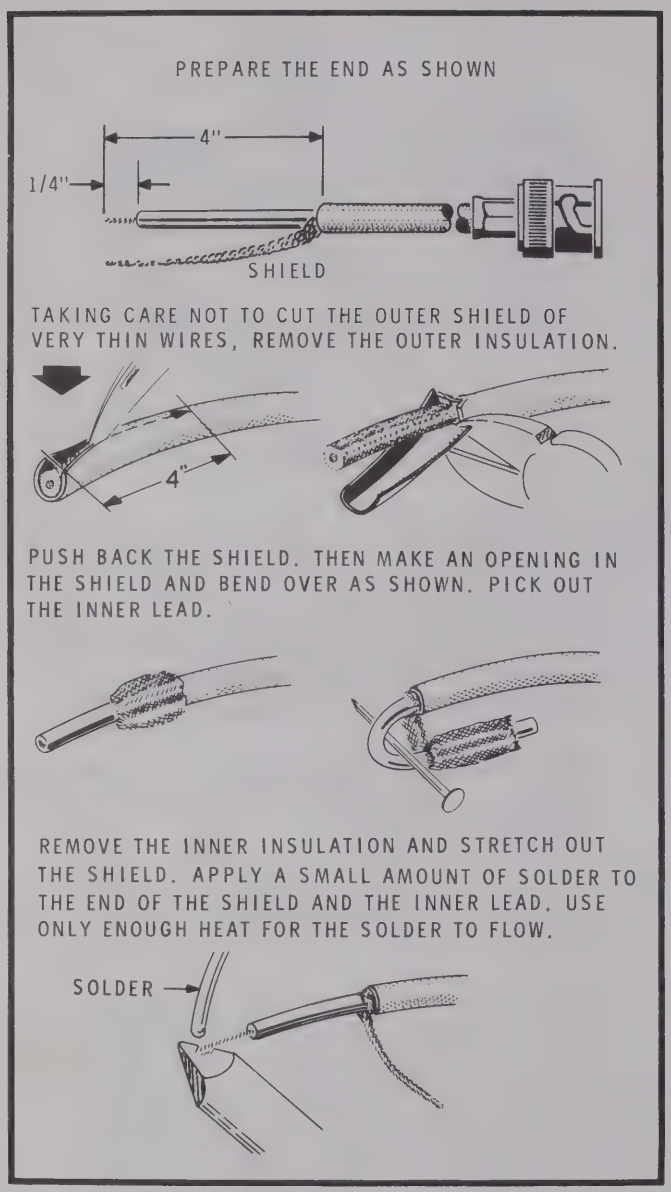
( ) Grasp the bushings you just installed and turn the switches fully counterclockwise.

( ) As before, install a red and black knob with 2 white indicators onto shaft SW301. Line up either of the white pointers with the Hz mark.

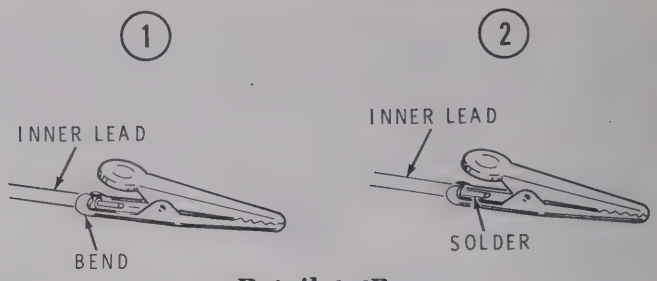
( ) As before, install a red and black knob with 1 white indicator onto shaft SW203. Line up the white pointer with the 1 mark.



Detail 4-4D


PREPARE THE END AS SHOWN
4"
1/4"
SHIELD
TAKING CARE NOT TO CUT THE OUTER SHIELD OF VERY THIN WIRES, REMOVE THE OUTER INSULATION.
4"
PUSH BACK THE SHIELD. THEN MAKE AN OPENING IN THE SHIELD AND BEND OVER AS SHOWN. PICK OUT THE INNER LEAD.
REMOVE THE INNER INSULATION AND STRETCH OUT THE SHIELD. APPLY A SMALL AMOUNT OF SOLDER TO THE END OF THE SHIELD AND THE INNER LEAD. USE ONLY ENOUGH HEAT FOR THE SOLDER TO FLOW.
SOLDER

Detail 4-5A



Detail 4-5B

INPUT CABLE ASSEMBLY

Refer to Pictorial 4-5 for the following steps.

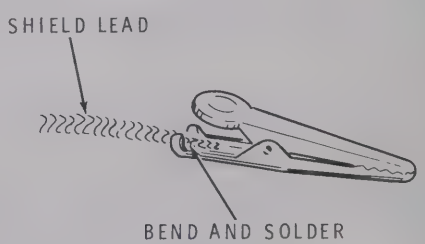
( ) Refer to Detail 4-5A and prepare the indicated end of the cable assembly.

( ) Refer to Pictorial 4-5 and push a rubber insulator onto the inner lead of the cable as shown.

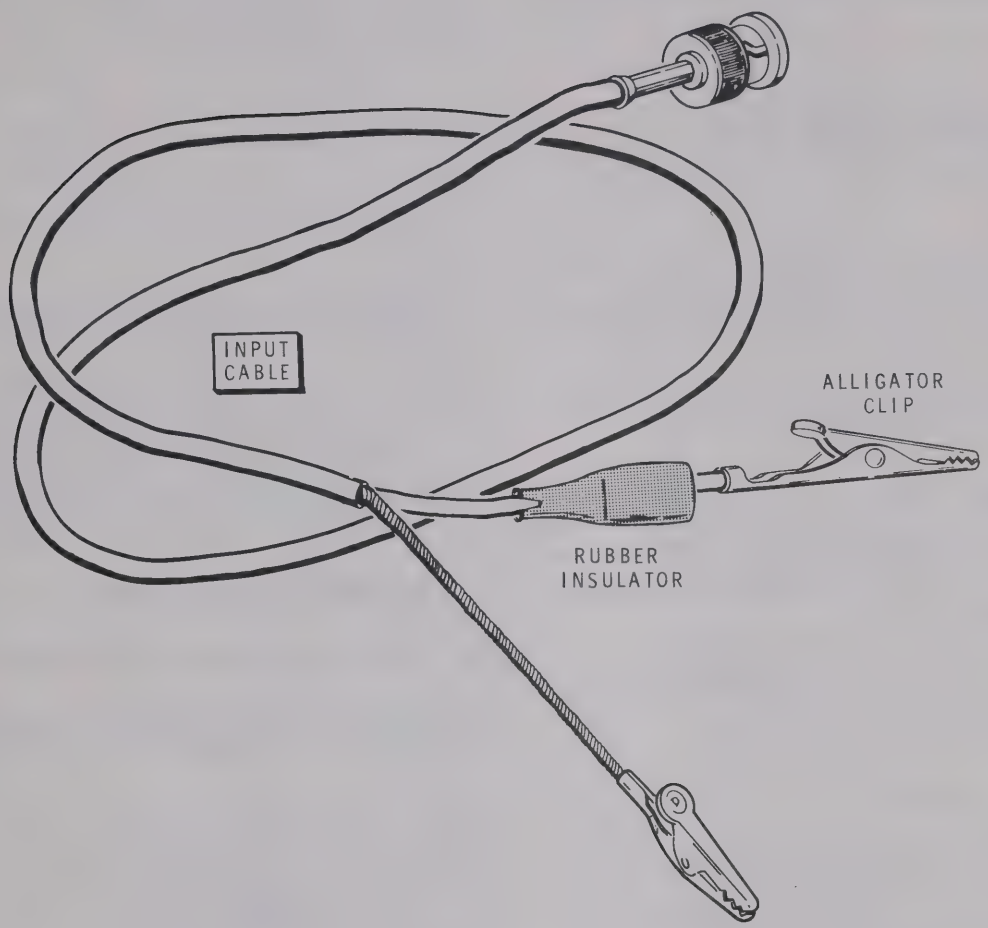
( ) Refer to Detail 4-5B and install an alligator clip on the inner lead of the cable as shown in parts 1 and 2 of the Detail. Then push the rubber insulator down over the alligator clip.

( ) Refer to Detail 4-5C and install an alligator clip on the shield lead of the cable as shown.

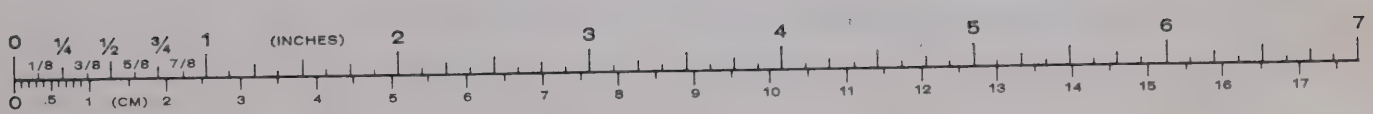
This completes the "Step-by-Step Assembly." Proceed to "Initial Tests."



Detail 4-5C



PICTORIAL 4-5



INITIAL TESTS

If not already done, set the front panel switches as follows. See Pictorial 4-4.

SW302 — FREQUENCY
SW301 — Hz
SW203 — 1
SW202 — 1 MΩ 110 MHz

NOTE: For the following steps, you will need an ohmmeter and a high input impedance DC voltmeter capable of reading 15 volts.

Refer to Pictorials 5-1 and 5-2 (Illustration Booklet, Pages 8 and 9) for the following steps.

NOTES:

1. Make sure you do not short any adjacent terminals or foils when you make tests or voltage measurements. If a probe or test lead slips, for example, and shorts together two adjacent connections, it is very likely to damage one or more of the transistors, diodes, or IC's.

2. Be especially careful when you test any circuit that contains an IC or a transistor. Although these components have an almost unlimited life when used properly, they are much more vulnerable to damage from excess voltage and current than many other parts.

3. Do not remove any components while the unit is turned on.

4. Handle MOS IC's properly. Static electricity can damage them.

5. Use a voltmeter with a high input impedance when you measure voltages.

( ) Connect the ohmmeter's common lead to a clip pin.

( ) Put the ohmmeter in the R × 10 position.

( ) Connect the ohmmeter test lead to the three lugs of rear panel connector J6, one at a time. The center lug should produce a reading of zero ohms and the other two should read infinite. (If not, check the connector wiring.)

( ) Disconnect the ohmmeter leads.

( ) Set rear panel switch SW3 to the INT position.

( ) Disconnect connector J5 from plug P301 and position the connector out of the way.

NOTE: Each of the tests below is identified with a capital letter. If you do not obtain the proper results in any of these tests, unplug the line cord and then proceed to the appropriate part of the "Initial Test Difficulties" on Page 67 (Test A, B, etc.) to locate and correct the problem. If you cannot solve the problem, proceed to "In Case of Difficulty." Do not proceed to another test until you obtain the proper results.

WARNING: When the line cord is connected to an AC outlet, line voltage is present at several places in your kit. Be careful that you do not contact this voltage or an electrical shock will result. See the "Circuit Board X-Ray View" on Page 17 of the Illustration Booklet. Also be sure that the loose green wire does not touch any of the circuitry.

( ) Connect the common lead of your voltmeter to a clip pin and set your voltmeter to measure +15 volts DC.

( ) Connect the line cord to rear panel connector J6 and then plug the line cord into an AC outlet.

Refer to Pictorial 5-2 (Illustration Booklet, Page 9) for the locations of the following test points.

NOTE: As you make the following measurements, record the voltage measurements beside the steps for future reference. Consider the accuracy of your meter. The values below were measured with a high input impedance voltmeter.

A. ( ) Measure test point 1 (TP1) for +7V to +13V DC.

( ) Set your voltmeter to measure −15 volts DC.

B. ( ) Measure test point 2 for −7V to −13V DC.

( ) Unplug the line cord.

( ) Reconnect connector J5 to plug P301.

( ) Turn switch SW2 clockwise until it just clicks.

( ) Set your voltmeter to read +5.25 volts DC.

( ) Plug in the line cord.

C. ( ) Measure test point 3 for +4.75V to +5.25V DC.

D. ( ) Measure test point 4 for +4.75V to +5.25V DC.

( ) Set your voltmeter to read −5.5 volts DC.

E. ( ) Measure test point 5 for −4.9V to −5.5V DC.

( ) Unplug the line cord.

NOTE: In the following steps, when you install an integrated circuit, refer to Detail 5-2A, (Illustration Booklet, Page 9), remove the IC from its packing material (if necessary), and install the IC as shown.

When you remove an IC from its package, check it to be sure that it has at least one of the numbers on it that is called for in the step. If it does not have one of these numbers, write the numbers that are on it beside the step. This will keep the IC's from becoming mixed up if you ever remove several IC's.

Some of the IC's are packed in conductive foam. These IC's are rugged and reliable components. However, normal static electricity discharged from your body through an IC pin to an object can damage the IC. Install these IC's without interruption as follows:

1. Remove the IC from its package with both hands.

2. Hold the IC with one hand and straighten any bent pins with the other hand.

3. Refer to Detail 5-2A. Then position the pin 1 end of the IC over the index mark on the circuit board.

4. Be sure each IC pin is properly started into the socket. Then push the IC down.

5. If after you install an IC, you do not get the proper test result, recheck the power supply voltages.

( ) IC333: Install an NE555V IC (#442-53) at IC333.

( ) Carefully turn the kit upside down.

( ) Set your voltmeter to read +3.75 volts DC.

( ) Plug in the line cord.

F. ( ) Refer to Detail 5-2B (Illustration Booklet, Page 9) and measure the voltage at test point 6 (IC340 pin 12) for 1.5V to 3.25V DC.

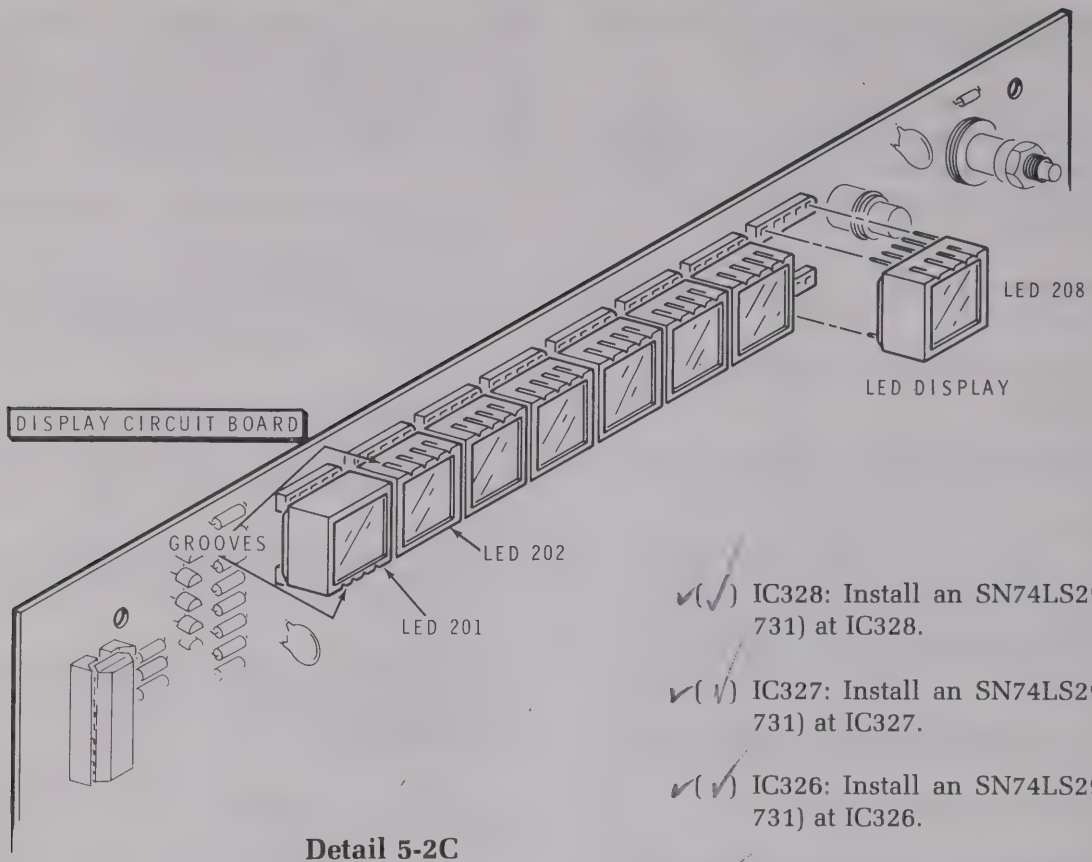
( ) Unplug the line cord.

( ) Carefully turn the kit right side up.

( ) IC340: Install an SN7472 IC (#443-4) at IC340.

( ) Set your voltmeter to measure −15 volts DC.

( ) Plug in the line cord.



Detail 5-2C

G. ( ) Measure test point 7 for −13V to −17V DC.

( ) Set your voltmeter to measure +15 volts DC.

H. ( ) Measure test point 8 for +13V to +17V DC.

( ) Unplug the line cord.

( ) IC341: Install an SN74LS74 IC (#443-730) at IC341.

( ) IC342: Install an SN74LS00 IC (#443-728) at IC342.

( ) IC331: Install an SN74LS293 IC (#443-733) at IC331.

( ) IC330: Install an SN74LS00 IC (#443-728) at IC330.

( ) IC329: Install an SN74LS290 IC (#443-731) at IC329.

( ) IC328: Install an SN74LS290 IC (#443-731) at IC328.

( ) IC327: Install an SN74LS290 IC (#443-731) at IC327.

( ) IC326: Install an SN74LS290 IC (#443-731) at IC326.

( ) IC325: Install an SN74LS00 IC (#443-728) at IC325.

( ) Set your voltmeter to measure +5 volts DC.

( ) Plug in the line cord.

J. ( ) Measure test point 9 for +1.8V to +5V DC.

J. ( ) Again measure test point 9 and push front panel pushbutton switch SW201. The voltage should increase at least .1 volt.

( ) Unplug the line cord.

( ) Disconnect the voltmeter and set it aside.

( ) IC321: Install an MC14518 IC (#443-737) at IC321.

( ) IC309: Install an MC14556 IC (#443-738) at IC309.

( ) IC320: Install an MC14025 IC (#443-712) at IC320.

( ) IC332: Install an MC14512 IC (#443-735) at IC332.

( ) Remove the knobs and front panel and set them aside temporarily.

In the following steps, install the following IC's and displays on the display circuit board. See Pictorial 5-1.

( ) IC201: Install a 74LS247 IC (#443-711) at IC201.

( ) IC202: Install an MC14025 IC (#443-712) at IC202.

( ) IC203: Install an MC14028 IC (#443-713) at IC203.

( ) LED201: Refer to Detail 5-2C and notice the grooved side of the LED displays. Position the grooves **down** and install an LED display in the sockets at LED201. Be sure the pins are straight and each pin goes into a socket hole.

( ) LED202 through LED208: Position the grooves **up** and mount the remaining seven LED displays in the remaining sockets.

K. ( ) Plug in the line cord. The decimal point in LED207 should light. (See Detail 5-2D.) The overange indicator in LED201 may light or it may be off. Either condition is correct.

( ) Temporarily reinstall the front panel and the black and red knob with two white indicators on switch SW301.

K. ( ) Rotate switch SW301 clockwise through its other positions. The following decimal points will light in the order listed. The overrange indicator will remain in its present condition.

LED205
LED206
LED204
LED205

( ) Return the switch to its full counterclockwise position.

( ) Prepare both ends of the remaining length of white wire.

L. ( ) Touch one end of the white wire to test point 10 and the other end to test point 11. The overrange indicator should now be on.

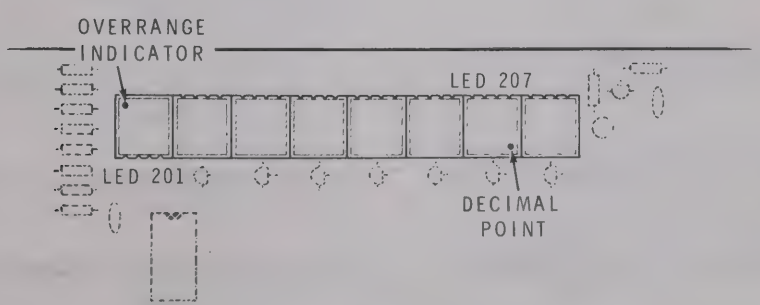
L. ( ) Touch one end of the wire to test point 11 and the other end to test point 12. The overrange indicator should be off. NOTE: The lamp may go out as soon as the wire is removed from pin 11.

( ) Unplug the line cord.

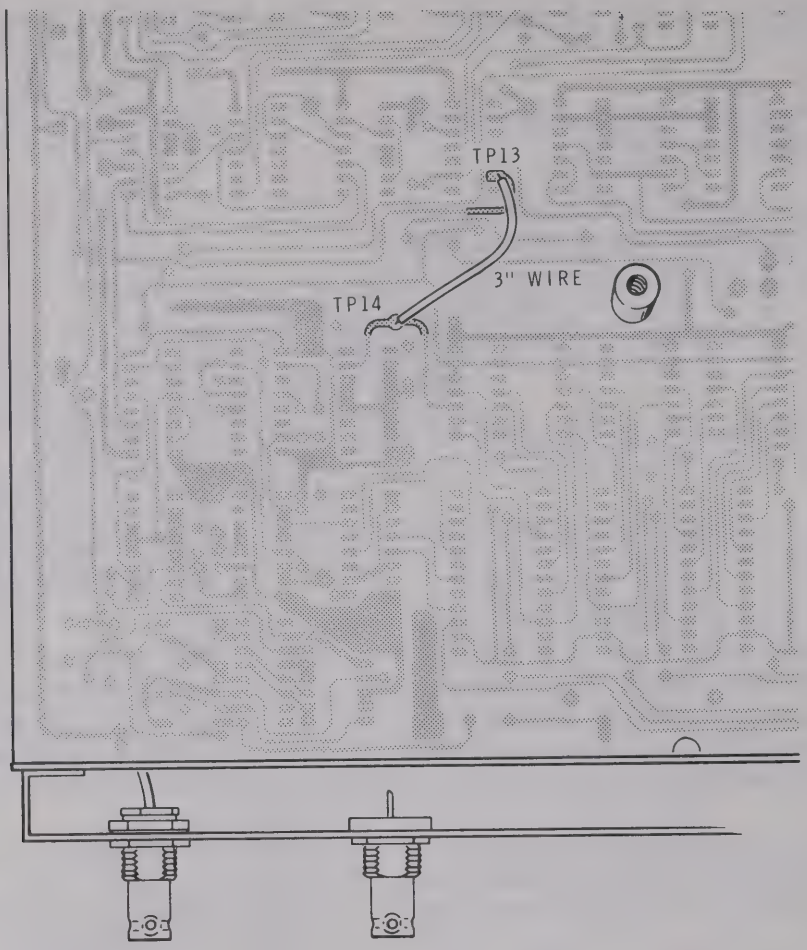
( ) Refer to the inset drawing on Pictorial 5-1 and temporarily solder one end of the white wire to the foil at display circuit board hole G. Be careful. Do not let hole G get filled with solder. For the remaining tests, this wire will be referred to as the test lead.

( ) Carefully turn your kit upside down.

( ) Prepare a 3" leftover wire.



Detail 5-2D



Detail 5-2E

( ) Refer to Detail 5-2E and temporarily solder the wire between test point 13 (IC325 pin 6) and test point 14.

( ) Carefully turn the kit right side up.

( ) IC313: Install an SN74LS290 IC (#443-731) at IC313.

( ) IC314: Install an SN74LS290 IC (#443-731) at IC314.

( ) IC315: Install an SN74LS290 IC (#443-731) at IC315.

( ) IC316: Install an MC14518 IC (#443-737) at IC316.

( ) IC317: Install an MC14518 IC (#443-737) at IC317.

( ) IC318: Install a CD4001 IC (#443-695) at IC318.

( ) IC319: Install a CD4013AE IC (#443-607) at IC319.

( ) IC305: Install an MC14508 IC (#443-736) at IC305.

( ) IC306: Install an MC14508 IC (#443-736) at IC306.

( ) IC307: Install an MC14508 IC (#443-736) at IC307.

( ) IC308:Install an MC14508 IC (#443-736) at IC308.

NOTE: Disregard any numbers or parts of numbers displayed in the following tests. Also, the decimal point will be repositioned as in earlier tests.

( ) Plug in the line cord. The overrange indicator should come on, the decimal point in LED207 may light and LED209 (the GATE lamp) should be off.

M. ( ) Touch the test lead to test point 3. LED209 should light.

N. ( ) Touch the test lead to test point 15. LED209 should flash at a 10 Hz rate.

N. ( ) Touch the test lead to test point 16. LED209 should flash at a 1 Hz rate.

( ) Turn switch SW301 to the second kHz position.

N. ( ) Touch the test lead to test point 17. LED209 should flash at a 10 Hz rate.

N. ( ) Touch the test lead to test point 18. LED209 should flash at a 1 Hz rate.

( ) Turn switch SW301 to the second MHz position,

N. ( ) Touch the test lead to test point 19. LED209 should flash at a 10 Hz rate.

N. ( ) Touch the test lead to test point 20. LED209 should flash at a 1 Hz rate.

P. ( ) Touch the test lead to test point 21. Then push pushbutton switch SW201. The overrange indicator will turn off, if it was on in a previous step, and LED209 will be off. After 10 seconds, LED209 will turn on and remain on as long as you hold the test lead at the test point. While you hold the test lead at the test point, push pushbutton switch SW201. LED209 will turn off again for 10 seconds.

( ) Unplug the line cord.

( ) IC338: Install an SN74LS13 IC (#443-729) at IC338.

( ) IC339: Install a 96L02 IC (#443-727) at IC339.

( ) Turn switch SW301 to the Hz position.

( ) Temporarily put the black knob onto switch SW302 and turn it to the EVENTS OP position.

Q. ( ) Plug in the line cord. The display will turn on and start counting upwards. LED208 will remain at 0. (LED208 may go blank after approximately 30 seconds.)

( ) Unplug the line cord.

( ) IC322: Install an SN74LS00 IC (#443-728) at IC322.

( ) IC323: Install an SN74LS74 IC (#443-730) at IC323.

( ) IC324: Install an SN74LS00 IC (#443-728) at IC324.

( ) Carefully turn your kit over and remove the wire you temporarily soldered to the circuit board earlier.

( ) Carefully turn the kit right side up.

( ) Plug in the line cord.

R. ( ) Touch the test lead to test point 22. LED209 should light.

( ) Turn switch SW302 to the EVENTS CL position.

S. ( ) Again touch the test lead to test point 22. LED209 should remain off.

( ) Unplug the line cord.

( ) IC334: Install an SN74LS30 IC (#443-732) at IC334.

( ) IC335: Install an SN74LS290 IC (#443-731) at IC335.

( ) IC336: Install an SN74LS290 IC (#443-731) at IC336.

( ) IC337: Install an SN74LS290 IC (#443-731) at IC337.

( ) Turn switch SW302 to the FREQUENCY position.

( ) Plug in the line cord.

( ) Again touch the test lead to test point 22 and then pushbutton switch SW201. LED209 will turn on for 10 seconds, blink off, and then turn on again and keep repeating.

T. ( ) Turn switch SW2 clockwise 1/2 turn and repeat the above step. LED209 will be off longer this time.

T. ( ) Turn switch SW2 fully clockwise and again repeat the previous test. LED209 will be off for longer than 60 seconds. (You need not wait over 60 seconds. It may not come back on.)

( ) Unplug the line cord.

( ) Remove the test lead and solder the indicated green wire to hole G in the display circuit board.

( ) IC301: Install an MC10216 IC (#443-723) at IC301.

( ) IC302: Install an MC10211 IC (#443-677) at IC302.

( ) IC303: Install an MC10211 IC (#443-677) at IC303.

( ) IC304: Install an MC10125 IC (#443-725) at IC304.

( ) IC310: Install an MC10124 IC (#443-724) at IC310.

( ) IC311: Install an MC10138 IC (#443-726) at IC311.

( ) IC312: Install an MC10211 IC (#443-677) at IC312.

( ) Connect the input cable to the 1 MΩ 110 MHz input connector.

( ) Connect the signal lead to connector J4 lug 1. Do not connect the ground lead.

U. ( ) Plug in the line cord and push the RESET button. After 10 seconds, the display should be 1000000.0.

( ) Unplug the line cord.

Install the following two IC's on the input circuit board. See Pictorial 5-1.

( ) IC105: Install an 11C01 IC (#443-714) at IC105.

( ) IC106: Install an 11C70 IC (#443-715) at IC106. NOTE: Install this IC in the opposite direction as compared to the other IC.

( ) Connect the input cable to the 50 Ω 250 MHz input connector.

( ) Position toggle switch SW202 to the 50 Ω 250 MHz position.

( ) Set input circuit board control R117 to its center of rotation.

V. ( ) Plug in the line cord and push the RESET button. After 10 seconds, the display should be 1000000.0.

( ) Unplug the line cord.

( ) Disconnect the input cable and set it aside.

This completes the "Initial Tests." Proceed to "Final Assembly."

INITIAL TEST DIFFICULTIES

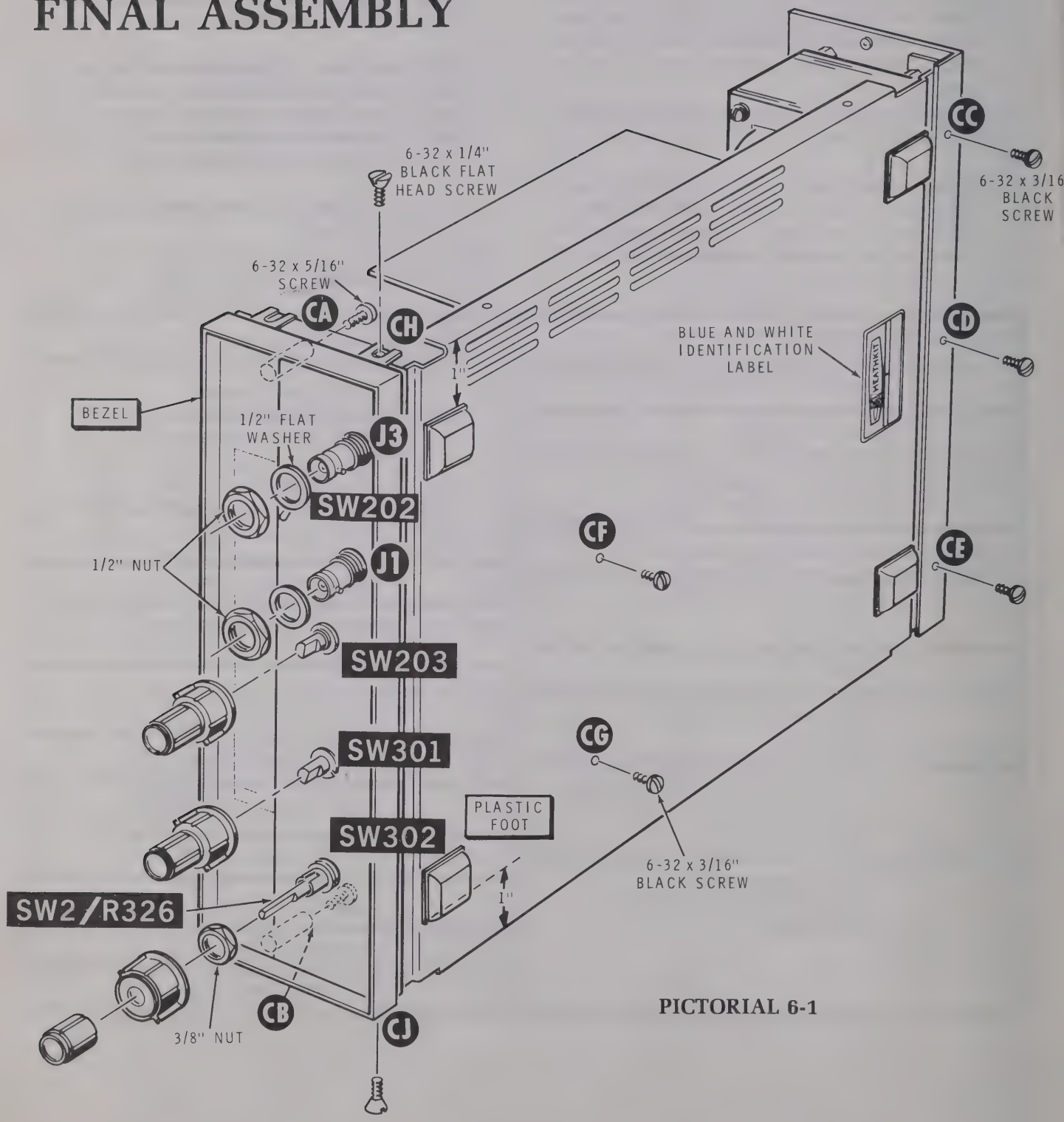
NOTES:

1. The following chart lists parts to check. These parts indicate areas of the circuits where problems could exist. Check the circuitry and look for an assembly error or **solder bridge**. Parts are rugged and reliable. Consider a part to be bad last.
2. Never apply +5, −5.2, or ground potentials to the output of any IC.
3. If you make a repair, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you find a damaged resistor, be sure you find out what damaged the resistor. If the cause is not eliminated, the replacement resistor may also become damaged when you put the unit back into operation.
4. In several areas of the circuit boards, the foil patterns are quite narrow. When you unsolder a part to check or replace it, avoid excessive heat while you remove the part. A suction-type desoldering tool makes part removal easier.
5. Use a DC oscilloscope to see waveforms and DC levels if necessary.

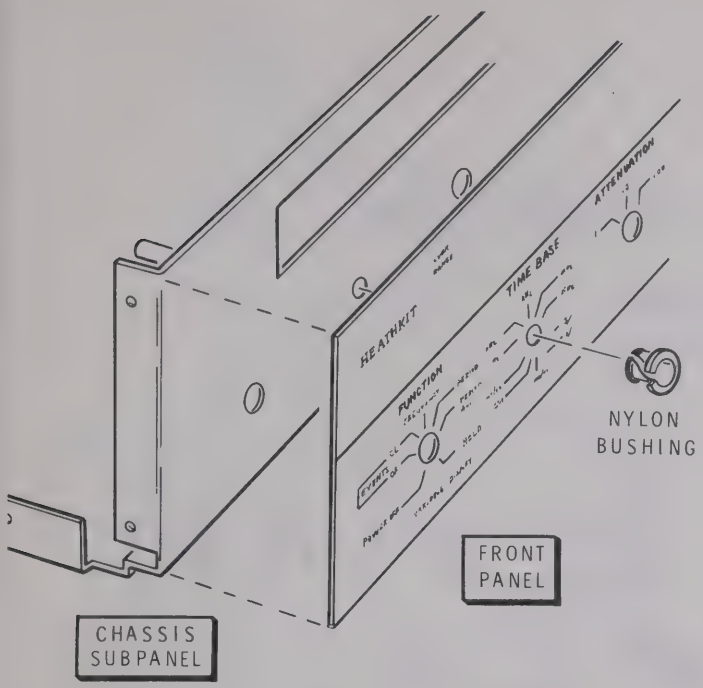
TEST	CHECK:
A	F301, SW1, D315, D317, C337.
B	D314, D316, C337.
C	IC343, C311, C315, C321, C331, Q307, Q308, C324.
D	IC345, C310, C332, C201.
E	IC344, C307, C309, C327, C130, C115.
F	IC333.
G	IC340, D312, D313, C323, C132, IC107.
H	D310, D311, C322, ZD105, IC101, IC102, IC103, ZD204, Q218, Q219.
J	Nine IC's just installed, IC346, TCXO, INT/EXT switch on back panel.

TEST	CHECK:
K	All IC's just installed, Q212, Q213, Q214, Q215, Q208, Q209, Q210,Q211, Q202, Q203, D302, D303, D304, D305.
L	IC332, IC201, IC202.
M	LED209, Q216, D203.
N	IC313, IC314, IC315, IC316, IC317.
P	IC318, IC319, IC325, D307, D306.
Q	IC307, IC308, IC305.
R	SW302, IC322, IC323, IC324.
S	SW302, IC322, IC323, IC324.
T	IC339, Q304.
U	IC334, IC335, IC336, IC337.
V	250 MHz input circuit.

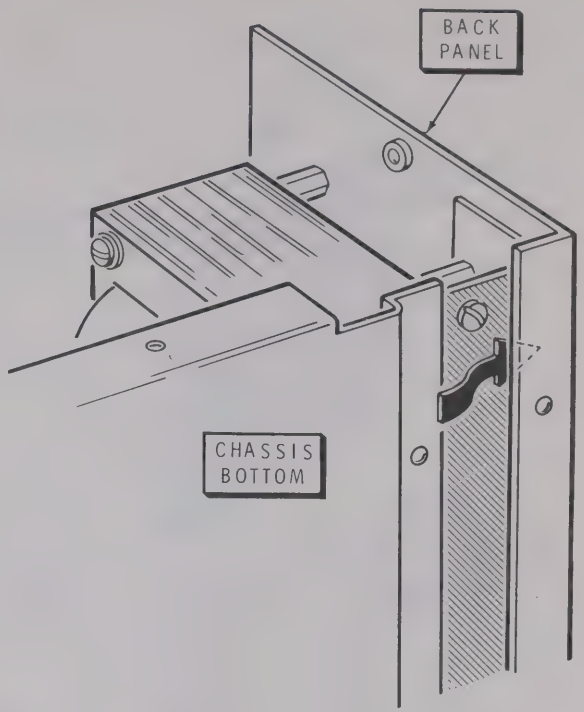
FINAL ASSEMBLY



PICTORIAL 6-1



Detail 6-1A



Detail 6-1B

Refer to Pictorial 6-1 for the following steps.

( ) Remove the knobs and front panel from your kit.

( ) Remove the protective coating from the front panel.

( ) Refer to Detail 6-1A and mount a nylon bushing in the front panel and chassis at hole SW301.

( ) Refer to Detail 6-1B and slide the circuit board assembly into the chassis as shown. Be sure the rear edge of the chassis is on top of the back panel ledge. Guide toggle switch SW202 through its hole.

( ) Secure the front panel at J1 and J3 with two 1/2" flat washers and two 1/2" nuts.

( ) Install a 3/8" nut at SW302.

( ) Secure the two units together with two 6-32 × 5/16" screws at CA and CB, and five 6-32 × 3/16" black screws at CC, CD, CE, CF, and CG. Start all the screws into their holes before you tighten any of them. If the holes do not line up, recheck the dimension on Page 55.

( ) Position the bezel into place over the front panel and secure it at CH and CJ with 6-32 × 1/4" black flat head screws.

Again mount the knobs as follows:

( ) Black knob at SW302. Be sure the white pointer is positioned properly.

( ) Red knob at SW2/R326.

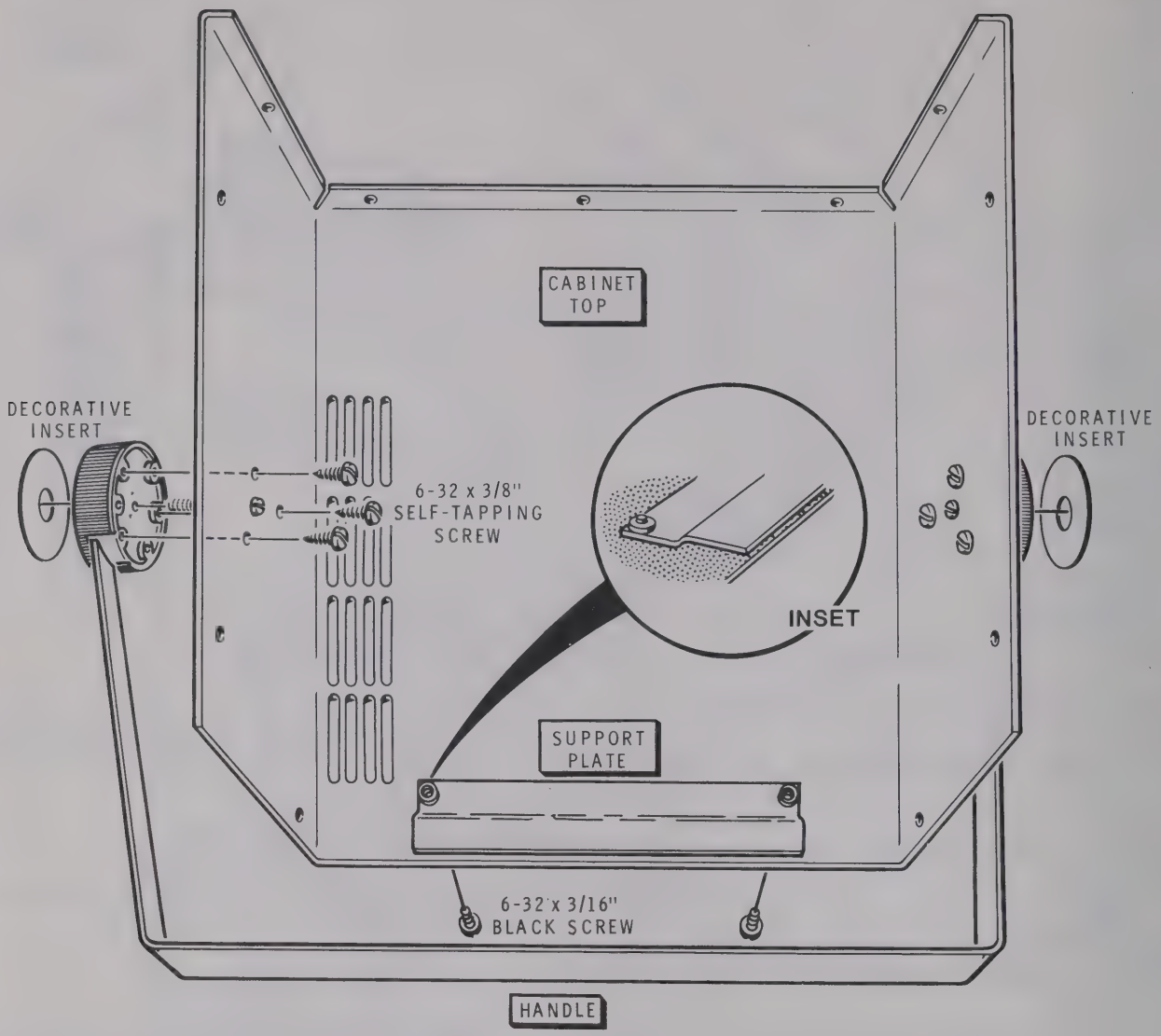
( ) Black and red knob with 2 white pointers at SW301.

( ) Black and red knob with 1 white pointer at SW203.

( ) Mount four plastic feet as shown. Remove the paper backing and press each foot into place.

( ) Carefully peel away the backing paper from the blue and white identification label. Then press the label onto the chassis bottom. Be sure to refer to the numbers on this label in any communication you have with Heath Company about this kit.

( ) Set the kit aside temporarily.



PICTORIAL 6-2

Refer to Pictorial 6-2 for the following steps.

( ) Refer to the inset drawing and mount the support plate to the cabinet top as shown. Use two 6-32 × 3/16″ black screws.

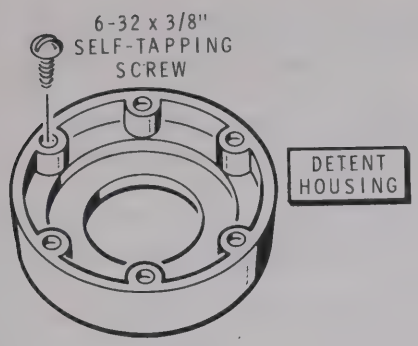
Prepare one end of the handle as follows:

( ) 1. Refer to Detail 6-2A and install a 6-32 × 3/8″ self-tapping screw in one of the six holes in a detent housing. Then remove the screw and install it in the other five holes one at a time to prethread the holes.

( ) 2. Refer to Detail 6-2B and assemble a detent housing, detent bushing, and detent button as shown.

( ) 3. Position the handle as shown, line up the flats of the detent bushing with the handle hole flats, and force the detent bushing into the handle hole as far as it will go.

( ) 4. Position a detent cover into place and secure it with a 1/2″ nut. Do not overtighten the nut.



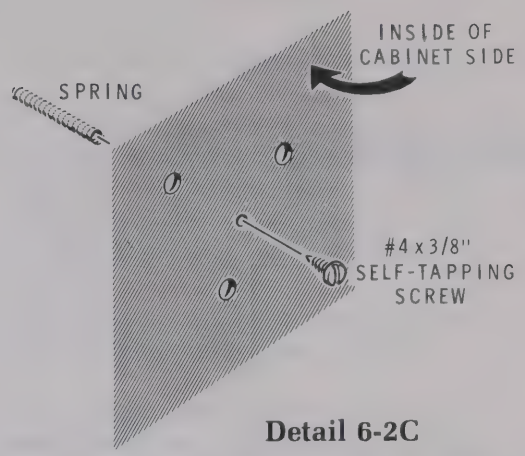
Detail 6-2A

( ) Repeat the previous four steps to prepare the other end of the handle.

( ) Refer to Detail 6-2C, turn the cabinet top upside down, and install a #4 × 3/8" self-tapping screw in the center hole in one side of the cabinet top as shown.

( ) In a similar manner, install another #4 × 3/8" self-tapping screw in the other side of the cabinet top.

( ) Again, refer to Detail 6-2C and turn a spring onto each screw as shown.



Detail 6-2C

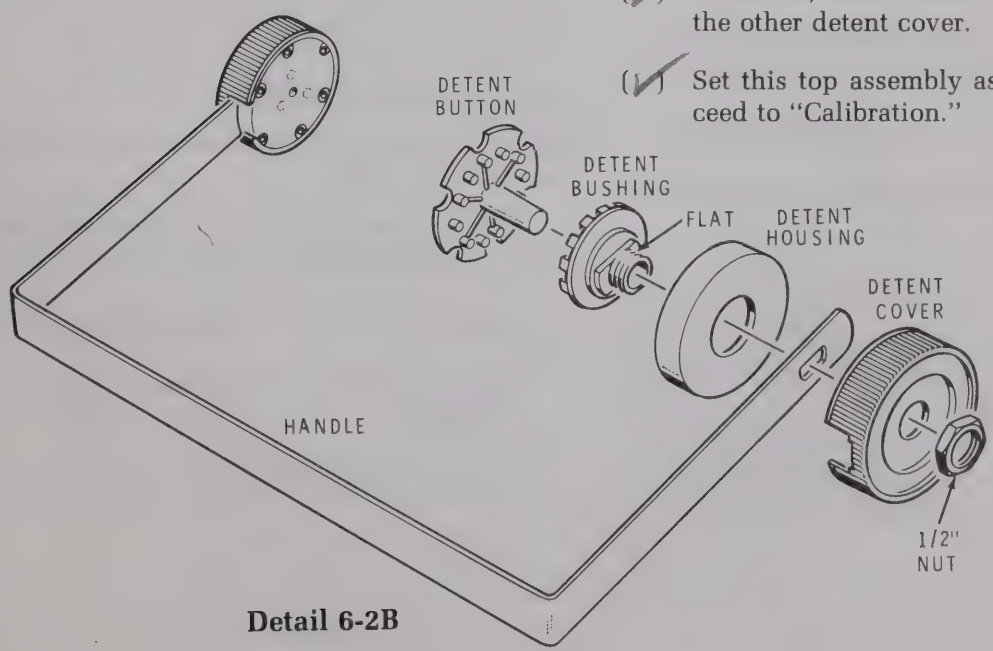
( ) Mount the handle on one side of the cabinet top with three 6-32 × 3/8" self-tapping screws. Be sure the spring goes into the hole properly and does not get bent over or pinched between the detent parts and the cabinet top. Start all three screws before you tighten any of them.

( ) In a similar manner, mount the other end of the handle to the cabinet top. Operate the installed detent and reposition the handle if necessary.

( ) Remove the backing paper from a decorative insert and press the insert into place with either of the detent covers.

( ) As before, install the other decorative insert in the other detent cover.

( ) Set this top assembly aside temporarily. Proceed to "Calibration."



Detail 6-2B

CALIBRATION

The accuracy of your Frequency/Period Meter depends to a great extent upon the care and accuracy with which you perform the following steps. If at any time you do not obtain the results called for in a step, refer to the "In Case of Difficulty" section to correct the problem.

This section of the Manual contains two calibration procedures. If you have access to a 250 MHz frequency generator, an oscilloscope, and a laboratory 1 MHz frequency standard, proceed to the "With Instruments" procedures on this Page. If these instruments are not available, proceed to the following "Without Instruments" procedure.

WITHOUT INSTRUMENTS

( ) Plug in the line cord and allow the Frequency/Period Meter to warm up for 30 minutes.

( ) Set the FUNCTION switch to FREQUENCY.

( ) Set the TIME BASE switch to the first MHz position.

( ) Set the INPUT switch to 50 Ω 250 MHz.

( ) Refer to Pictorial 7-1 (Illustration Booklet, Page 10) and, using a small-bladed screwdriver, turn input circuit board control R117 counterclockwise until a 0.0001 appears on the display. Then slowly turn this control clockwise until the display is just 0.0000; then stop.

( ) Unplug the line cord.

NOTE: If you have purchased the IMA-4130-1 Battery Pack Accessory kit, proceed to that Manual and assemble and install the Accessory kit. Then return to the following step in this Manual.

( ) Refer to Pictorial 7-2 (Illustration Booklet, Page 10), position the cabinet top in place, and secure it at EA and EB with 6-32 × 3/8″ black screws. Install 6-32 × 3/16″ black screws at the other nine locations. Start all the screws before you tighten any of them.

This completes the "Calibration" of your kit. Proceed to the "Operation" section and read that information.

WITH INSTRUMENTS

Refer to Pictorial 7-3 (Illustration Booklet, Page 11) for the following steps.

( ) Plug in the line cord and allow the Frequency/Period Meter to warm up for 30 minutes.

( ) Set the FUNCTION switch to FREQUENCY.

( ) Set the TIME BASE switch to the first MHz position.

( ) Set the INPUT switch to 50 Ω 250 MHz.

Input Adjustment

( ) Connect a 250 MHz, 110-millivolt signal to the 50 Ω 250 MHz front panel connector.

( ) Adjust control R117 on the input circuit board until the correct frequency is displayed.

( ) Reduce the generator's signal amplitude until the display becomes unstable or goes to zero.

( ) Slowly turn control R117 clockwise to again obtain a correct display.

( ) Repeat the above two steps until the point is reached where the smallest generator signal possible still produces a correct display.

( ) Disconnect the generator from the input connector.

( ) Unplug the line cord.

NOTE: If you have purchased the IMA-4130-1 Battery Pack Accessory kit, proceed to that Manual and assemble and install the Accessory kit. Then return to the following step in this Manual.

( ) Refer to Pictorial 7-2, position the cabinet top in place, and secure it at EA and EB with 6-32 × 3/8″ black screws. Install 6-32 × 3/16″ black screws at the other nine locations. Start all the screws before you tighten any of them.

( ) Plug in the line cord and allow the unit to warm up for 30 minutes.

Refer to Pictorial 7-4 (Illustration Booklet, Page 11) for the following steps.

( ) Connect the laboratory 1 MHz frequency standard to the Y input of your oscilloscope.

( ) Connect a cable between the OSCILLATOR OUTPUT/INPUT connector on the back panel of your kit and the external trigger input of your oscilloscope. (Be sure the INT EXT back panel switch is in the INT position.) You may use the regular X input if your oscilloscope does not have the external trigger input.

( ) Place the oscilloscope Time/Cm switch in the X-Y position and adjust the oscilloscope controls for a display similar to that shown in Pictorial 7-4.

( ) With a small-bladed nonmetallic screwdriver adjust the TCXO of the Frequency/Period Meter through the back panel until the oscilloscope pattern stops "turning."

( ) Unplug the line cord.

( ) Disconnect the frequency standard and oscilloscope.

This completes the "Calibration" of your kit. Proceed to the "Operation" section and read that information.

OPERATION

Refer to Pictorial 8-1 on Page 12 in the "Illustration Booklet" for a description of the display, controls, and switches.

CAUTION: Use ONLY the center conductor of the input lead of your Meter to check the frequency of an AC line voltage. Connecting the ground input lead to the "hot" (ungrounded) side of an AC line may result in a blown fuse and/or damage to your Meter.

INPUTS

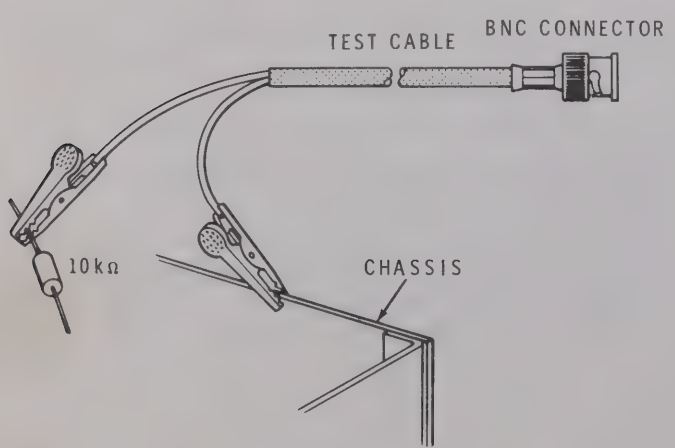
The 110 MHz input has an input impedance of 1 MΩ shunted by approximately 18 pF of capacitance. When you measure pulses or square waves of high amplitude and fast rise time (rise time ≤ 50 nanoseconds and amplitude ≥ 200 mV), connect a 1/4-watt resistor (approximately 10 kΩ) in series with the test cable (see Pictorial 8-2) to eliminate reflections in the test cable.

This is necessary because reflections will distort the waveform, which can cause erroneous readings — or possibly damage the equipment under test. Also, capacitive loading can cause the unit under test to change frequency and result in erroneous readings.

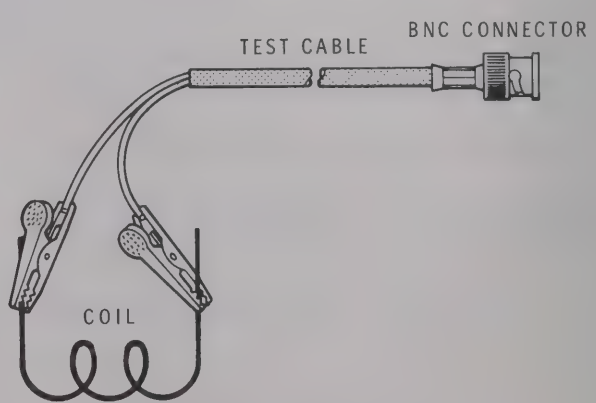
A simple way to reduce reflections and capacitive loading is to use a 10 MΩ, divide-by-10 oscilloscope probe. This decreases the input sensitivity somewhat, but does provide isolation between the unit under test and your Frequency/Period Meter.

When you measure frequencies from a transmitter with a power greater than 1/2-watt, use a coupling coil in place of a direct connection. Three turns of a hook-up wire connected to the end of the test cable, as shown in Pictorial 8-3, will provide enough signal to trigger the Meter. Place the coil just close enough to the signal source for the Meter to count. NOTE: **Do not** connect the ground to the transmitter and place the coil in the same axis as the transmitter coil or around the antenna. See Graph A for a typical input Sensitivity Curve.

The 250 MHz input has an input impedance of 50 ohms; and therefore, will properly terminate a 50-ohm transmission line. If you use test cables other than 50 ohms, it will then be necessary to use a matching pad to eliminate reflections and capacitive loading. See the following typical input curves on graphs A through C.

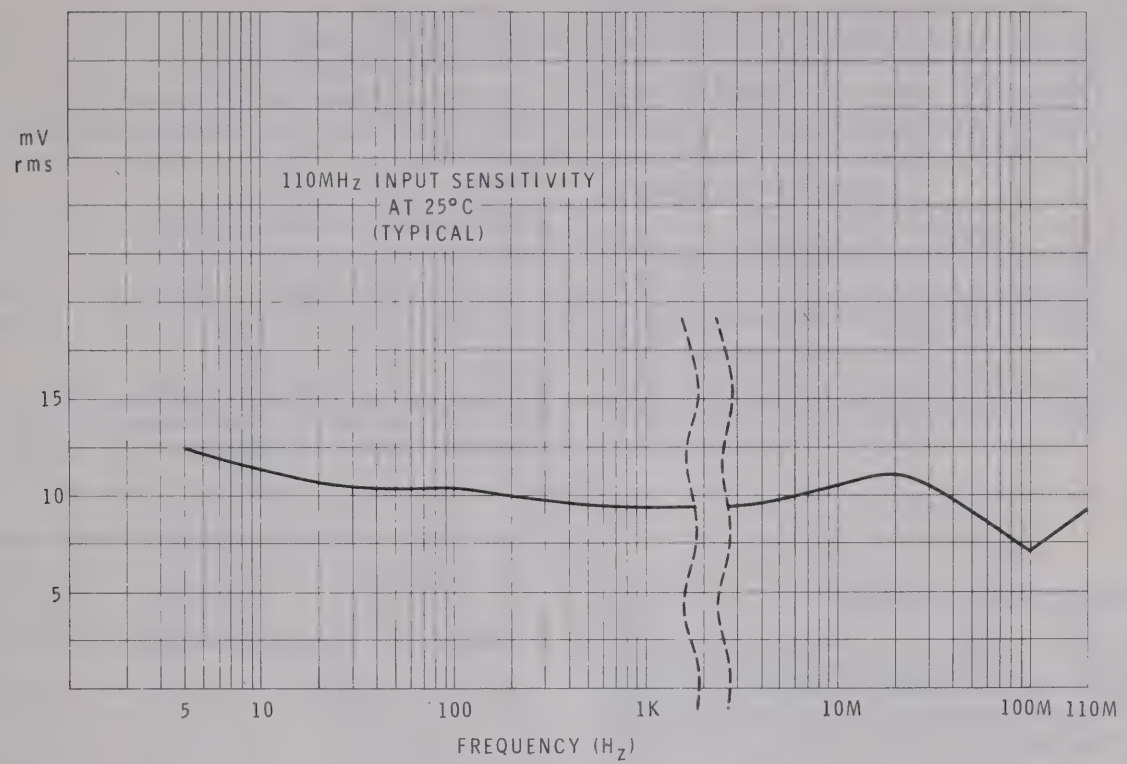


PICTORIAL 8-2

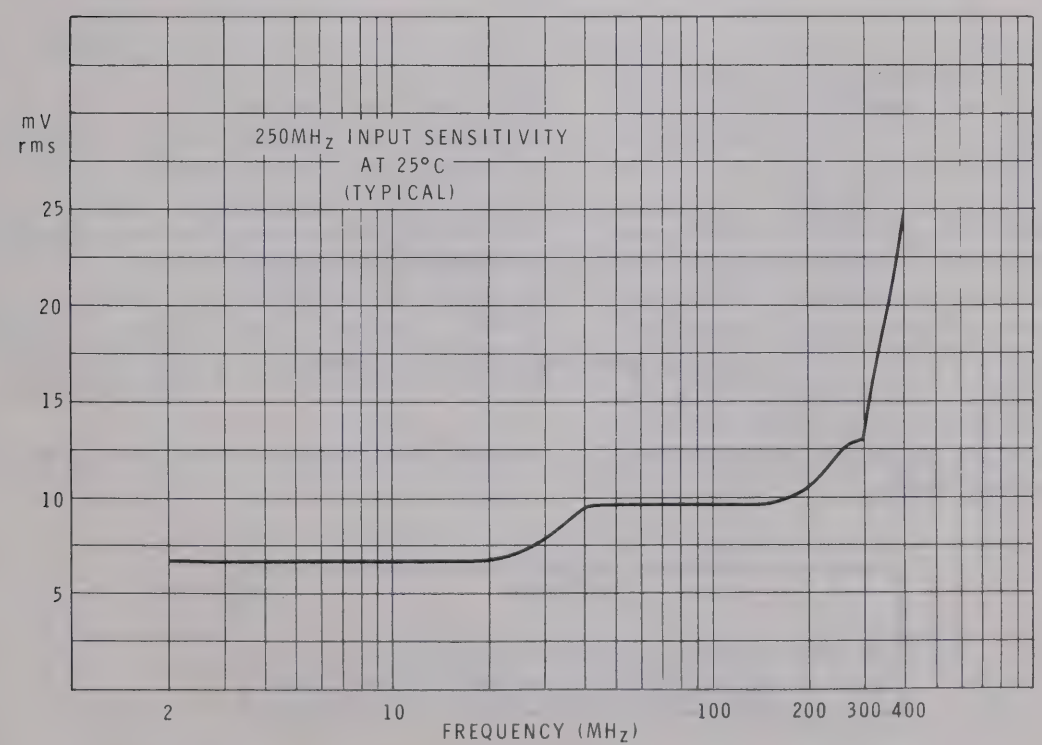


PICTORIAL 8-3

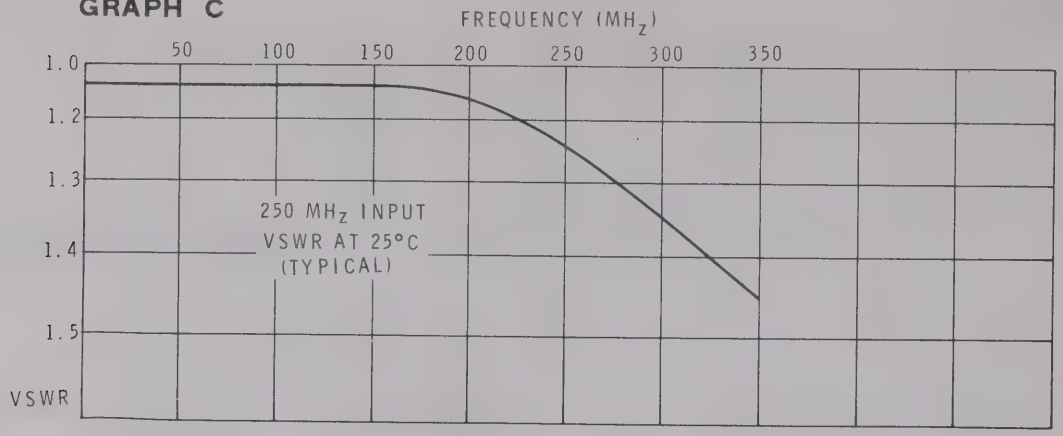
GRAPH A



GRAPH B



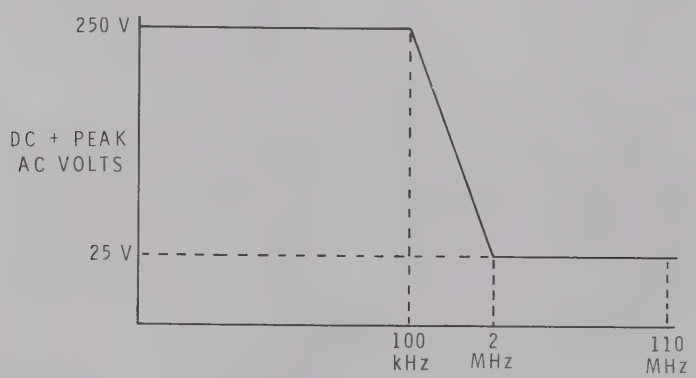
GRAPH C



MAXIMUM INPUT VOLTAGE

The 110 MHz input can withstand 250 volts, DC plus peak AC, up to a frequency of 100 kHz. Above this frequency, the maximum input voltage must be derated according to graph D.

GRAPH D



110 MHz INPUT DERATING CURVE

The 250 MHz input is protected to 5 volts rms throughout its frequency range.

CAUTION
DO NOT connect a transmitter output directly to an input of this instrument under any circumstances.

FREQUENCY MODE

With the FUNCTION switch in the FREQUENCY position, you can measure any frequency between 5 Hz and 250 MHz. Connect the equipment under test to the appropriate front panel input and read the frequency from the display.

The TIME BASE switch selects the reference time (gate time) over which the counting circuitry makes its measurement, and thus, selects the resolution of the display.

As you rotate the TIME BASE switch counterclockwise, the gate time increases in decade steps to a maximum of 10 seconds with a resulting resolution of .1 Hz.

TIME BASE SWITCH POSITION	RESOLUTION	110 MHz 250 MHz GATE TIME
Hz	.1 Hz	10 Sec.
kHz	1 Hz	1 Sec.
kHz	10 Hz	100mSec.
MHz	100 Hz	10mSec.
MHz	1000 Hz	1mSec.

EVENTS MODE

The FUNCTION switch has two positions for this mode: EVENTS OP and EVENTS CL. EVENTS OP opens the input gate and permits the counting circuitry to increment for each input pulse. The resulting counts are displayed by the readout. EVENTS CL closes the input gate; thus inhibiting any additional counting. However, the readout retains its present information. To start a new count cycle, push the front panel RESET button and rotate the FUNCTION switch to EVENTS OP.

You can use either of the inputs in the EVENTS mode.

PERIOD

With the FUNCTION switch in the PERIOD mode, and a signal applied to the 110 MHz input, the readout will display the period of the input signal. The TIME BASE switch selects the desired resolution.

PERIOD AVERAGE

With the FUNCTION switch in the PERIOD AVERAGE position and a signal applied to the 110 MHz input, the readout will display the time required for 1000 periods. However, the blue scale on the TIME BASE switch is now used and thus the displayed information is converted to the equivalent single period time.

ACCURACY

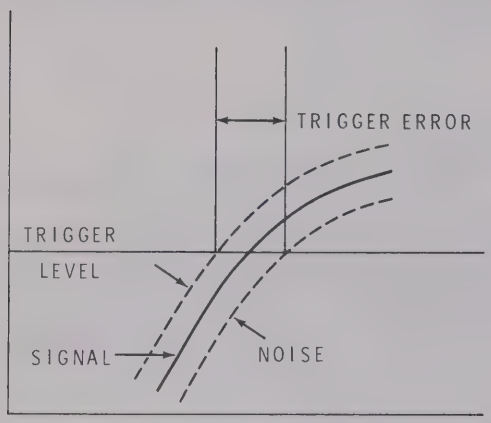
In the FREQUENCY mode, the accuracy of the Frequency/Period Meter depends on the accuracy of the time base oscillator and the inherent ±1 count error of the instrument. Thus, for a ±1 PPM time base accuracy, the instrument has an accuracy of ±1 Hz, ±1 count for a 1 MHz input signal. Likewise, for a 200 MHz input signal, the instrument has an accuracy of ±200 Hz, ±1 count.

The quality of the input signal affects the measurement capabilities of this instrument. A signal with a 40 dB signal-to-noise ratio can cause inaccuracies as well as one with a 20 dB signal-to-noise ratio. For example: a 2V rms signal with a 40 dB signal-to-noise ratio will have 20mV rms noise content. Since 20mV rms is more than the input requires to trigger, the instrument will count the noise in addition to the fundamental input signal. If, however, the input signal is attenuated by a factor of 10, then the instrument sees a 200mV rms signal with only 2mV rms of noise. Thus, the noise is ignored and only the fundamental input signal is counted.

In the EVENTS mode, the time base is not used. Consequently, only the quality of the input signal (as discussed earlier) affects the count accuracy.

In the PERIOD and PERIOD AVERAGE modes, the greatest cause of inaccuracy is the input signal. It can be shown that, for a sine wave with a signal-to-noise ratio of 40 dB, the worst case trigger error is ±.32% of the measured period. Likewise, a 20 dB ratio results in a ±3.2% error, and a 60 dB ratio results in a ±0.032% error. This is shown in Graph E.

GRAPH E



Obviously, if a fast rise signal is to be measured, the trigger error will be substantially reduced since the noise has less time to influence the input circuitry.

The effective trigger error can be reduced by using the period averaging technique. Although the absolute trigger error remains unchanged, it only occurs at the beginning of the first period and the end of the last period. Consequently, the error is reduced by the number of periods averaged.

ACCURATE LOW FREQUENCY MEASUREMENTS

Your Meter counts and displays low frequency signals. However, the display error will be ±1 count because the internal clock is not synchronized with the incoming signal. To measure a low frequency signal more accurately, position the TIME BASE switch to mS and the FUNCTION switch to PERIOD. Then solve for the equation F (in Hertz) = 1/period (in seconds).

EXAMPLE: Accurately count a 10 Hz signal from a signal generator.

The period display is 99.991 mS.

Solve for f = 1/period = 1/.099991 = 10.0009 Hz.

IN CASE OF DIFFICULTY

WARNING: When the line cord is connected to an AC outlet, hazardous voltages are present at several places inside your Frequency/Period Meter. See the X-Ray View (Illustration Booklet, Page 17).

This section of the Manual is divided into two parts. The first part, titled "Troubleshooting and Repair Precautions," points out the care that you should use when you service the unit to prevent damaging components.

The second part, titled "Troubleshooting Chart" gives difficulties and likely causes.

If the "Troubleshooting Chart" does not help you locate the problem, read the "Circuit Description" and refer to the Schematic Diagram (fold-in) to help you determine where the trouble is.

NOTE: In an extreme case where you are unable to resolve a difficulty, refer to the "Customer Service" information inside the rear cover of the Manual. Your Warranty is located inside the front cover.

TROUBLESHOOTING AND REPAIR PRECAUTIONS

Be sure you disconnect the line cord before you remove the cabinet from your Frequency/Period Meter.

1. Make sure you do not short any adjacent terminals or foils when you make tests or voltage measurements. If a probe or test lead should slip, for example, and short together two adjacent connections, it is very likely to damage one or more of the transistors, diodes, or IC's.

2. Be especially careful when you test any circuit that contains an IC or a transistor. Although these compoents have an almost unlimited life when used properly, they are much more vulnerable to damage from excess voltage and current than many other parts.

3. Do not remove any components while the unit is turned on.

4. Handle MOS IC's properly. Static electricity can damage them.

5. Use a voltmeter with a high input impedance when you measure ECL voltages.

6. Never apply +5, −5.2, or ground potentials to the output of any IC.

7. When you make repairs, make sure you eliminate the cause as well as the effect of the trouble. If, for example, you should find a damaged resistor, be sure you find out what damaged the resistor. If the cause is not eliminated, the replacement resistor may also become damaged when you put the unit back into operation.

8. In several areas of the circuit boards, the foil patterns are quite narrow. When you unsolder a part to check or replace it, avoid excessive heat while you remove the part. A suction-type desoldering tool makes part removal easier.

COMPONENTS

To remove faulty resistors or capacitors; first clip them from their leads, then heat the solder on the foil and allow each lead to fall out of its hole. Preshape the leads of the replacement part and insert them into the holes in the circuit board. Solder the leads to the foil and cut off the excess lead lengths.

You can remove transistors in the same manner as resistors and capacitors. Make sure you install the replacement transistor with its leads in the proper holes. Then solder the leads quickly to avoid heat damage. Cut off the excess lead lengths.

FOIL REPAIR

To repair a break in a circuit board foil, bridge solder across the break. Bridge large gaps in the foil with bare wire. Lay the wire across the gap and solder each end to the foil. Carefully trim off any excess bare wire.

TROUBLESHOOTING CHART

NOTE: It is normal for ECL IC's to be quite warm during operation.

PROBLEM	POSSIBLE CAUSE
One digit does not display, or displays an E continuously.	1. LED display. 2. Cathode driver transistor. 3. Cathode driver transistor decoder. IC203.
Same segment in all displays is either continuously on or off.	1. Segment driver transistor. 2. 7-segment decoder; IC201.
More than one decimal point on at the same time, or no decimal points are on.	1. Data selector, IC332. 2. Transistors; Q220, Q303, Q302. 3. IC202. 4. Diodes D302, D303, D304, D305.
Leading zeros are not blanked.	1. 7-segment decoder; IC201, Q201, Q202, Q203, Q204, Q205, Q206, Q207. 2. Zero blanking gate, IC202. 3. Strobe reset, IC320.
One segment of one display never lights.	1. LED display.
Unit operates in Event Op mode, but Gate lamp is off.	1. Gate lamp circuitry; LED209, Q216, D203.
Unit does not operate in Event Op mode, but Gate light is on.	1. Input amplifier. 2. Counting DCU's IC311, IC313, IC314, IC315, IC316, IC317. 3. Memory defeat circuitry; D306, D307.
Unit continues to count in Events CI mode.	1. Gate logic; IC323, IC324, IC310.
Unit does not operate in Frequency Mode, Gate lamp flashes.	1. Input amplifier. 2. Counting DCU's IC311, IC314, IC314, IC315, IC316, IC317. 3. Memory circuit; IC338, IC339, IC325.
Unit does not operate in Frequency mode, Gate lamp is always on or always off.	1. Time base circuitry; TCXO, IC341, IC342, IC331, IC330, IC329, IC328, IC327, IC326. 2. Hold-off circuitry, IC339, IC325.
Unit operates in Frequency mode, but display is terribly incorrect.	1. Reset circuitry; IC329, IC325. 2. Input signal has high noise content. 3. Reflections on input test cable. 4. See next problem.
Unit operates in Frequency mode, but display is incorrect by a factor of 1000.	1. Divide-by-1000 circuitry, IC334, IC335, IC336, IC337, IC322.
Unit does not operate in Period mode, but Gate light flashes.	1. Time base circuitry; TXCO, IC341, IC342, IC331, IC330, IC326, IC327, IC328, IC329. 2. Reset circuitry; IC311, IC313, IC314, IC315, IC316, IC317. 3. Memory circuitry; IC339, IC325, IC338.
Unit does not operate in Period mode and Gate lamp does not flash.	1. Input amplifier. 2. Gate logic; IC323, IC324, IC322, IC310.
Unit operates in Period mode, but not in Period Average mode.	1. Divide-by-1000 circuitry; IC334, IC335, IC336, IC337, IC322.

SPECIFICATIONS

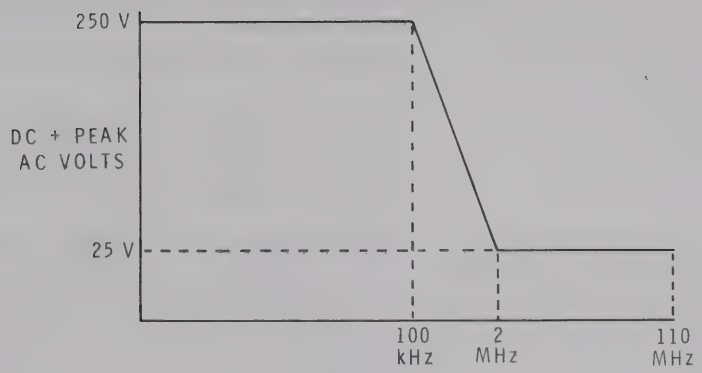
FUNCTIONS

Events	1 to 99,999,999.
Frequency	5 Hz to 250 MHz.
Period Resolution	.1 μS.
Period Average	Average of 1,000 periods.

INPUTS

	110 MHz	250 MHz
Frequency Range	5 Hz to 110 MHz.	5 MHz to 250 MHz.
Sensitivity	25mV rms.	25mV rms.

	110 MHz	250 MHz
Period Pulse Width	100ns minimum.	
Low Frequency Signal Rise time	1ms for signals less than 10 Hz.	
Input Impedance	1 MΩ shunted by < 25 pF.	50 Ω. VSWR < 1.5:1.
Protection	250V (DC + peak AC) to 100 kHz. See derating curve.	5V rms.



110 MHz INPUT DERATING CURVE

	110 MHz	250 MHz
Attenuator	X1, X10, X100 fixed compensation	

TIME BASE

Setability	±.1 PPM.
Frequency	4 MHz TCXO
Aging Rate	< 5 PPM/year.
Temperature Stability	±1 PPM 0° to 40° Ambient.

OSCILLATOR CONNECTION

External Input Frequency	1 MHz.
External Input Sensitivity	TTL or 2.5V rms from 50-ohm source.
External Input Protection	−5V peak to +10V peak.
Internal Output	> 1.5V P-P into 50 ohms at 1 MHz.
TCXO Warmup	10 minutes.

GENERAL

Gate Interval

Frequency	1 mS to 10S.
Period	Determined by period of input frequency.
Period Average	1000 periods of input frequency.
Display Time	200 mS to 20S including a count hold position.
Power Requirements	105-130 or 210-260 VAC (switch selected), 50-60 Hz, (at 35 watts); or 9-14 VDC at 2.50 amperes with IMA-4130-1 Accessory.
Dimensions	10-1/4″ wide × 13-1/4″ deep × 4″ high (less handle). (26 cm wide × 33.7 cm deep × 10.2 cm high.)
Weight	8 lbs. 3.6 kg.

The Heath Company reserves the right to discontinue products and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

CIRCUIT DESCRIPTION

The Circuit Description is divided into two sections; "Theory of Operation" and "Detailed Description." The Theory section briefly describes overall instrument operation in block circuit format. The Detailed sections examines all of the circuit components and their interrelationships. Before you read the Detailed section, read the Theory section. This will help put the individual circuit components into perspective.

As you read this section, refer to the Block Diagram (Illustration Booklet, Page 13) and the Schematic (fold-in). Various timing diagrams are also referenced in the Detailed Description to help clarify some of the logic functions.

THEORY OF OPERATION

SIGNAL INPUT

Two separate inputs are provided to accommodate signal parameters encountered at various frequencies. The 110 MHz amplifier consists of a protected high impedance FET/Bipolar pair and a 3-stage IC (integrated circuit) amplifier. The 250 MHz amplifier is a 3-stage, wide band, transistor amplifier with a 50-ohm input impedance.

FREQUENCY MEASUREMENT

110 MHz Counter

With the 110 MHz amplifier selected, the input signal is routed through the gate control circuit to the divide-by-2 section of the first decade counter. The frequency is divided and routed through multiplexer B to the divide-by-5 section of the first decade counter. The output of the first decade counter is translated from its ECL logic level parameter to TTL logic and coupled to the least significant digit (LSD) latch. Carryover from the first decade counter is also logic-level translated and coupled to the remaining decade counters. The precise time the input signal is allowed to increment the decade counters is determined by the time base and gate control circuits. After the time base rate is selected, it is further divided by the divide-by-1000 circuit before it is used to open and close the gate.

When the gate closes (ending a count cycle), a pulse is sent to the memory, reset, and hold-off circuits. These circuits force transfer of the accumulated count from the decade counters into the latches, reset the decade counters and overrange; and preset the time base, divide-by-1000 circuit, and gate logic in preparation for a new count cycle. The data transferred to the latches is multiplexed to the display LED's through the data driver.

Timing for the display function is generated by the scan strobe circuit. This circuit turns each display digit (LED package) on in succession at the rate of 100 μS per digit. At the same time, it instructs the digit selector to activate the appropriate latch and couple the stored data to the display.

Decimal point position is determined by the decimal point control circuit. Like the display digits, the decimal point is strobed on when the appropriate LED package is selected by the scan strobe circuit. Leading zero blanking is also determined by the decimal point control and data driver.

If the most significant digit (MSD) decade counter spills over during a count cycle, the overrange circuit will latch. This forces the decimal point control and data driver to strobe the overrange indicator at the end of each display cycle.

250 MHz Counter

With the 250 MHz amplifier selected, the input signal is routed to the 250 MHz divide-by-2 circuit. The frequency is divided and routed through multiplexer B to the divide-by-5 section of the first decade counter. The remaining signal flow is identical to that described for the 110 MHz counter.

PERIOD MEASUREMENT

With the function switch in the Period position, the time base is routed to the divide-by-2 section of the first decade counter. The input signal is routed to the gate control where it is used to gate the time base on and off. The count and display circuits function as described for the 110 MHz counter. Note that the time base is not routed through the divide-by-1000 circuit before it goes to the first decade counter.

When the period average mode is selected, the input signal is routed through the divide-by-1000 circuit before it can gate the time base off. Thus, one thousand periods are measured, and the display is changed by a factor of 1000. (If one period is measured in milliseconds, one thousand periods are measured in microseconds.)

EVENTS COUNTING

In the events mode; the input signal is routed to the divide-by-2 section of the first decade counter. The "gate" is held open (no time base). Thus, the decade counters will count each event. Counter memory is asserted (on) so the display will continuously update with each event.

DETAILED DESCRIPTION

LOGICAL CIRCUITS

Three types of integrated circuit (IC) logic are used in this instrument. It is important that you know the nominal voltage parameters for each type of logic to understand instrument operation. TTL and MOS logic use 0 volts for a logic low level and 5 volts for a logic high level. ECL logic uses a −1.6 volt for a logic low level and −.8 volt for a logic high level.

Exact voltage levels are as follows:

TTL logic high (input) = greater than 2 volts.

TTL logic high (output) = greater than 2.4 volts.

TTL logic low (input) = less than 0.8 volts.

TTL logic low (output) = less than 0.4 volts.

MOS logic high (input) = greater than 3 volts.

MOS logic high (output) = greater than 4.5 volts.

MOS logic low (input) = less than 2 volts.

MOS logic low (output) = less than 0.5 volts.

ECL logic high (input) = 0 volts to −1.1 volts.

ECL logic high (output) = 0 volts to −1.0 volts.

ECL logic low (input) = less than −1.5 volts.

ECL logic low (output) = less than −1.6 volts.

110 MHz INPUT AMPLIFIER

The input signal is coupled through input attenuator switch SW203 to the gate of FET Q218. Resistor R221 limits the low frequency current (input protection) to clamp diodes D201 and D202. Capacitor C204 is a high frequency bypass, while resistor R220 limits the high frequency current to a safe level. FET Q218 and transistor Q219 translate the high input impedance to the low drive impedance required by IC301. This is accomplished through negative feedback from the collector of Q219 to the source of Q218. The bipolar pair also supplies a small amount of voltage gain.

The output from the collector of Q219 is AC coupled to pin 9 of IC301, a 3-stage differential amplifier with an internal voltage reference source. The first two stages use negative feedback to stabilize their voltage gain characteristics and increase their frequency response. High frequency peaking is provided by capacitors C302 and C303. The third stage uses positive feedback to form a Schmitt trigger with an input hysteresis of approximately 330 mV peak-to-peak. This converts the amplified input signal into a fast-rise rectangular wave of proper amplitude to drive the ECL logic used in frequency and events measurement. Transistor Q301 translates the ECL logic levels, from IC301, to the TTL logic levels required for period measurement. Diode D301 biases the base of Q301 to approximately −0.6 volt to insure an accurate level translation.

250 MHz INPUT AMPLIFIER

The input signal is coupled through resistor R102 to the base of transistor Q101. Resistors R101, R102, R103, and the input resistance of Q101 form a 10 dB pi attenuator network. This provides a low VSWR (voltage standing-wave ratio) 50-ohm input. The coil in series with R103 compensates for the input capacitance of Q101. Diodes D101 and D102 clamp the input to a safe voltage level but do not materially affect the input VSWR.

Transistors Q101, Q102, and Q103 form a 3-stage wideband amplifier with inductive and capacitive shunt peaking in each stage. The printed circuit inductors in the base return of each stage provide inductive peaking to flatten the midband frequency response. The emitter capacitors (C101, C108, and C111) of each stage provide capacitive peaking to flatten the high frequency response. The series RC network in the emitter circuit of each stage sets the low frequency gain and 3 dB rolloff point.

The output from the collector of Q103 is coupled to emitter-follower Q104. Q104 provides the low output impedance needed to drive ECL logic. The inactive output voltage at the emitter of Q104 is set to approximately −1.3 volts by control R117 for optimum amplifier sensitivity. Resistors R121 and R122 provide line termination at the input IC106.

INPUT SELECTION

With Input Selector switch SW202 in the 110 MHz position, any signal from the 250 MHz, divide-by-2 circuit (IC106) is blocked in multiplexer B (IC303). This is forced by the ground from switch SW202 to pins 9 and 10 of IC303B. The ECL logic high (ground) on the NOR gate forces an ECL logic low on output pins 12, 13, and 14. Thus, only the signal from the 110 MHz amplifier can be counted or used for gating.

When SW202 is in the 250 MHz position, transistor Q217 is biased on, and places an ECL logic high on pins 6 and 7 of IC303 (multiplexer). This forces an ECL logic low on output pins 2, 3, and 4, and inhibits any output from pin 15 (110 MHz divide-by-2) of the first decade counter (IC311) from progressing to pin 7 of IC311. Pins 9 and 10 of IC303 switch to an ECL logic low. Therefore, any output from the 250 MHz divide-by-2 circuit (IC106) is coupled through IC303 to pin 7 (divide-by-5 input) of IC311.

A ground from switch SW202 is coupled to the input circuit board. It is used to bias transistor Q104 on so the 250 MHz amplifier signal can be coupled to pin 9 of IC106 (250 MHz divide-by-2). The ground is also coupled to multiplexer A (IC105). This ECL logic high on pin 7 of IC105A forces a logic low on output pin 3. The low from pin 3 of IC105A to pin 13 of IC105B lets the gate signal on pins 10, 11, and 12 couple through IC105B to pin 7 of IC106. Pins 9 and 7 of IC106 are connected to an internal OR gate, so the gate signal on pin 7 can modulate (gate) the input signal on pin 9. The output (pin 2) of IC106 is routed through IC303 to pin 7 (divide-by-5 input) of the first decade counter.

When either the 110 MHz or the 250 MHz input circuits are selected, a ground is coupled from switch SW202 to the time base circuit. This biases gate IC330B off and allows the clock to couple through gates IC330D and IC330C to the time base scaler.

COUNT CONTROL

Events Mode

In the Events mode of operation, Function switch SW302A applies ground (ECL logic high) to pins 9 and 10 of gate IC302B. This forces pins 12, 13, and 14 low and blocks the time base on pin 11. Switch SW302D applies ground (TTL logic low) to pin 13 of gate IC322D. This forces pin 11 high and blocks the 110 MHz input signal on pin 12. Switch SW302C applies ground (TTL logic low) to pin 1 of gate IC324A and blocks any hold-off pulses on pin 2. This ground is also used to clear monostables IC339A and IC339B, and force pin 8 of IC325C high. With pin 8 of IC325C (memory control) high, the display latches are allowed to track the events count for a continuous display update.

When Function switch SW302 is in the Events OP (open) position, switch SW302B applies ground (TTL logic low) to pin 10 of flip-flop IC323. This forces pin 9 high. Gate IC310B translates and inverts the high from pin 9 of IC323 to an ECL logic low. This lets the 110 MHz input signal couple through gate IC302A to pin 12 (divide-by-2 input) of the first decade counter.

After the events count is complete, Function switch SW302 is turned to the CL (closed) position. This removes ground from pin 10 of IC323. Pin 13 of IC324D remains high, and pin 12 is allowed to internally pull high. Thus, pin 11 is forced low and pin 9 of IC323 is also forced low. This low is translated and inverted to gate IC310B, which blocks the input signal at pin 12 of IC311. The accumulated events count will continue to be displayed until Manual Reset switch SW201 is pressed. This applies ground (TTL logic low) to pin 2 of gate IC325A (pin 1 is held high by IC339B) and forces a high at pin 3 to reset the decade counters.

Frequency Mode

In the Frequency mode of operation, Function switch SW302A applies ground (ECL logic high) to pins 9 and 10 of gate IC302B. This forces pins 12, 13, and 14 low and blocks the time base on pin 11. Switch SW302D applies ground (TTL logic low) to pin 13 of gate IC322D. This forces pin 11 high and blocks the 110 MHz input signal on pin 12. Pin 10 of gate IC322C is held high, which lets the time base couple through to pin 10 of IC324C. The high on pin 9 lets the time base couple through to pin 11 of flip-flop IC323 and pin 10 of counter IC337.

Refer to Pictorial 9-1 (Illustration Booklet, Page 14) for the control logic timing diagrams. Prior to a count cycle, IC323 is cleared by the hold-off signal from gate IC325D. This forces pin 8 high and pin 9 low. A high on pin 8 presets the divide-by-1000 counter to 999 and forces pin 8 of IC334 low, which forces pin 3 of gate IC322A high. The low from pin 9 of IC323 forces pin 6 of gate IC322B high. It also blocks the 110 MHz input signal at pin 12 of IC311 (through gate IC310B), and 250 MHz input signal at pin 7 of IC106 (through gates IC310A and IC105B).

The leading edge of the first time base cycle at pin 8 of IC324C clocks pin 9 of IC323 high (gate on). This high is inverted by gate IC322B and forces pin 12 of IC323 low (pin 4 of IC322B was high). The high from pin 9 of IC323 also unblocks the 110 MHz input signal at pin 12 of IC311 (through gate IC310B, and the 250 MHz input signal at pin 7 of IC106 (through gates IC310A and IC105B). Depending on the input selected, the first decade counter begins to count the input signal cycles.

The trailing edge of the first time base cycle at pin 8 of IC324C increments the divide-by-1000 counter (IC335, IC336, and IC337) from 999 to 0. This forces pin 8 of IC334 high, pin 4 of IC322B low, and pin 12 of IC323 high. With pin 12 of IC323 held high, pin 9 is forced high and will not be affected by subsequent time base cycles. However, each trailing edge of the time base will increment the divide-by-1000 counter. Pin 8 of IC334 will remain high until the 999 count; then it is forced low. This forces pin 3 of IC322A high and pin 12 of IC323 low. With pin 12 of IC323 low, the next leading edge of the time base will clock pin 9 of IC323 low (gate off). This blocks the input signal

through IC310A or IC310B. The falling edge of the signal at pin 9 of IC323 triggers hold-off monostable IC339A and memory monostable IC338A and B.

When hold-off monostable IC339A is triggered, the output, pin 7, goes low. This forces pin 11 of IC325D high, which resets time base scalers IC326, IC327, IC328, and IC329, disabling the time base output. The high at pin 11 is also inverted by gates IC324A, B, and D to clear flip-flop IC323 and insure that pin 9 of IC323 remains low. Hold-off remains active until the memory and reset monostables Q304 protects timing capacitor C319 from a reverse bias voltage, while control R326 and capacitor C319 set the hold-off time. At the completion of hold-off, pin 11 of gate IC325D goes low, and the first leading edge of the time base signal starts a new count cycle.

The high-to-low logic transition at pin 9 of IC323 also triggers memory monostable IC338A and B. This generates a low at pin 8 of IC338B and forces a high at pin 8 of gate IC325C. A high at pin 8 of IC325C lets the latch circuits update to the count stored in the decade counters. At the completion of memory, pin 8 of IC338B goes high and locks the new count in the display latches. Resistor R349 and capacitor C317 set the memory time, while diodes D308 and D309 provide reverse-bias voltage protection.

The low-to-high logic transition at pin 8 of IC338B (end of memory update) triggers reset monostable IC339B. This generates a low at pin 9 and forces a high at pin 3 of gate IC325A to reset the decade counters, set overrange detector IC319, and reset 250 MHz divide-by-2 counter IC106. At the completion of reset, pin 9 of IC339 goes high. Resistor R351 and capacitor C318 set the rest time.

The count control circuits can be manually reset at any time. When Manual Reset switch SW201 is pressed, ground is applied to pin 12 of gate IC325D, pin 2 of gate IC325A, and through diode D307 to pin 9 of IC325C. This ground activates hold-off, memory, and reset. It also clears monostables IC339A and B. Thus, after manual reset has been released, the next leading edge of the time base signal initiates a new count cycle. Diode D307 isolates pin 9 of gate IC325C from pin 2 of gate IC325A in the Events mode, when ground is applied by switch SW302C. Diode D306 prevents manual reset ground from affecting the decimal point control circuit.

Period Mode

In the Period mode of operation, Function switch SW302A applies ground (ECL logic high) to pins 5 and 6 of gate IC302A. This forces pins 2, 3, and 4 low and blocks the 110 MHz input signal. With pins 9 and 10 of IC302B open, the time base on pin 11 is allowed to couple through the gate to pin 12 of first decade counter IC311. The time base is translated to the required ECL logic levels by gate IC310C. Switch SW302D applies ground (TTL logic low) to pin 10 of IC322C. This forces pin 8 high and blocks the time base on pin 9. Pin 13 of gate IC322D is held high, which lets the 110 MHz input signal from the collector of transistor Q301, couple through to pin 9 of IC322C. The high on pin 10 lets the input signal couple through to pin 11 of the flip-flop IC323 and pin 10 of counter IC337.

When the single Period mode is selected, switch SW302E applies ground (TTL logic low) to pin 2 of gate IC322A. This forces pin 3 high and blocks the output of the divide-by-1000 counter on pin 1. Period Average will be described later.

Prior to a count cycle, IC323 is cleared by the hold-off signal from gate IC325D. This forces pin 9 low, which in turn forces pin 12 high and blocks the time base signal at pin 12 of IC311 (through gate IC310B). The leading edge of the first input signal cycle clocks pin 9 of IC323 high (gate on). This high forces pin 12 low and lets the time base increment the first decade counter (through IC310C). The next leading edge of the input signal will clock pin 9 of IC323 low (gate off). This forces pin 12 high and blocks the time base signal through IC310B. The falling of the signal at pin 9 of IC323 triggers the monostables for hold-off, memory, and reset, as described under "Frequency Mode." At the end of the hold-off, a new period measurement cycle is initiated.

If the Period Average mode is selected, switch SW302E does not ground pin 2 of gate IC322A. The high from pin 8 of IC323 (forced by "clear" from hold-off signal) presets the divide-by-1000 counter to 999 and forces pin 8 of IC334 low. This low forces pin 3 of IC322A high. The low from pin 9 of IC323 (forced by "clear" from hold-off signal) can then force pin 12 high, through gate IC322B.

The leading edge of the first input signal cycle at pin 8 of IC324C clocks pin 9 of IC323 high (gate on). This high forces pin 12 of IC323 low and also unblocks the time base at pin 12 of decade counter IC311, through IC310B.

The trailing edge of the first input signal cycle at pin 8 of IC324C increments the divide-by-1000 counter (IC335, IC336, and IC337) from 999 to 0. This forces pin 8 of IC334 high, pin 4 of IC322B low, and pin 12 of IC323 high. With pin 12 of IC323 high, pin 9 is forced high and will not be affected by subsequent input signal cycles. However, each trailing edge of the input signal will increment the divide-by-1000 counter. Pin 8 of IC334 will remain high until the 999 count; then it is forced low. This forces pin 3 of IC322A high and pin 12 of IC323 low. With pin 12 of IC323 low, the leading edge of the input signal will clock pin 9 of IC323 low (gate off). This blocks the time base at pin 12 of IC311 through gate IC310B, and triggers the hold-off, memory, and reset monostables as described under "Frequency Mode." At the end of hold-off, a new multiple period measurement cycle is initiated.

COUNT DISPLAY

Decade Counters

When the 250 MHz or 1 GHz input amplifiers are selected in the Frequency mode, their signals are divided-by-2 through IC106. The output of IC106 is coupled through gate IC303B to pin 7, the divide-by-5 section of first decade counter IC311. The signal is also coupled to the A input, pin 14 of translator IC304. IC311 counts the signal and couples the count information of IC304 in a binary coded decimal (BCD) word. The four lines of information (inputs A, B, C, and D) are translated to TTL logic levels and coupled to pins 22, 20, 18, and 16 (A, B, C, and D inputs) of latch IC305. When the memory monostable triggers at the end of a count cycle, a logic high is coupled to pin 14 of latch IC305. This forces the information on the A, B, C, and D inputs to load the latch.

If the 110 MHz input or the time base is selected as the counter signal, it is routed through the divide-by-2 section of the first decade counter IC311. The output is coupled through gate IC303A to pin 7 of IC311 and pin 14 of translator IC304. The remaining counter functions are identical for any input signal.

The C and D count information from first decade counter IC311 is coupled to pins 10 and 11 of translator IC321A and B. (The two gates of IC312 are wired to provide ECL to TTL level translation and operate as an OR gate.) Pin 15 of IC312B is high at the count of 9 and goes low at the count of 10. This high-to-low transition increments the second decade counter (IC313). Each decade counter (IC311, IC313, IC314, IC315, IC316, and IC317) continues to increment and carryover to the next counter until the end of the count cycle. Then the accumulated count is transferred to latches (IC305, IC306, IC307, and IC308) on command from the memory monostable, as BCD information. At the end of transfer, the latches are closed, and the decade counters are reset to zero in preparation for a new count cycle.

Overrange

If the accumulated count exceeds the decade counter capacity, overrange detector IC319 is activated. Prior to a count cycle, IC319 is set to a ready state by the reset monostable (pin 13 is high and pin 12 is low). Pin 11 of gate IC318D is high (memory off). This high forces pin 4 of gate IC318B low and pin 3 of gate IC318A low. When counter IC317 overranges, pin 10 of gate IC318C will shift from a low to high logic state. This forces flip-flop IC319B to clock, and set pin 1 of IC318A low and pin 6 of IC318B high. As the memory monostable updates the latches, it also forces pin 11 of gate IC318D low, pin 3 of gate IC318A goes high, and pin 2 of flip-flop IC319A high. Pin 2 of IC319A will remain high until it is set low by a logic high on pin 6 of IC319A.

Display Strobe

Timer IC333 is wired as an oscillator with an 80-kHz operating frequency. It provides the clock needed to strobe the display. Pictorial 9-2 (Illustration Booklet, Page 15) illustrates the timing required to transfer the accumulated count in the latches to the display LED's (light-emitting diodes). Counter IC321 contains two divide-by-10 counters that are used to generate the strobe information. The A output, pin 3, of IC321A supplies a 40 kHz signal to the clock input, pin 9 of IC321B. The D output, pin 6 of IC321A supplies a 10 kHz signal to the enable input, pin 10 of IC321B. Each time pin 10 goes high, the next leading edge of the signal at pin 9 increments counter IC321B. Thus, output A (pin 11) supplies a 4 kHz signal, output B (pin 12) supplies a 2 kHz signal, and output C (pin 13) supplies a 1 kHz signal.

Output D (pin 14) is the ninth count (BCD format) in IC321B and is used to reset IC321B. As pin 14 goes high, strobe-reset monostable IC320A and IC320B is toggled. This supplies a high to pin 15 of IC321B (reset), pins 3 and 4 of gate IC202B, and pin 10 of data selector IC332. Resistor R333 and capacitor C312 determine monostable timing.

The three control lines (A, B, and C) from counter IC321B determine the count information sequencing. They are connected to dual binary decoder IC309, BCD-to-decimal decoder IC203, and data selector IC332.

Dual binary decoder IC309 contains two 4-line decoders. Data lines A (pins 2 and 14) and B (pins 3 and 13) determine the logic levels for each decoder, while data line C (pins 1 and 15) selects either decoder (C is inverted by gate IC320C before it is connected to pin 1). Each output pin is normally high unless it is selected by the data lines. Refer to Pictorial 9-2. If data lines A, B, and C are low, pin 12 of IC309 will be forced low while the remaining output pins stay high.

A low on pin 12 of IC309 will activate the four output lines of latch IC308A. The output lines of the latches are tri-state (that is, active high, active low, and open or high impedance). Therefore, all of the latches can share a 4-line data bus; since the outputs of only one latch are active at any time. The count information from latch IC317A is coupled to the 4-line input of BCD-to-seven segment decoder IC201. IC201 converts the BCD information into seven lines of display segment information. If the number you wish to display is 8, the BCD data lines are A-low, B-low, C-low, and D-high. This data code forces all seven of the output pins low (active state). A low on an output pin will turn on its associated segment driver transistor. In this example, all seven segment-driver transistors are turned on and place +5 volts on the seven lines of the display data bus.

The three data lines from counter IC321B, that selected latch IC308A through decoder IC309, also control BCD-to-decimal decoder IC203. As shown in Pictorial 9-2, when latch IC308A is selected, pin 3 of IC203 goes high and turns digit-driver transistor Q208 on. Q208 supplies ground to LED201 and the data on the 7-line display buss turns on the selected segments of the LED.

The D output (pin 6) of counter IC321A is coupled to pin 11 of IC203. It supplies an 8 kHz pulse of short duration to "blank" the output pins of IC203. This insures that each digit-driver transistor has time to turn off before the next transistor is turned on by IC203.

Data selector IC332 is also controlled by the three data lines from counter IC321B. The information selected is decimal point placement, overrange status, and leading-zero blanking. Time Base switch SW301 and Function switch SW302 select the desired decimal point position. Depending on the operating mode, ground from SW302 turns off either transistor Q302 or Q303, or both Q302 and Q303. Switch SW301 directs the +5 volts from the active transistor to the appropriate input pin on IC332.

Overrange status is coupled to pin 1 (logic high active). Each of the eight input pins is sampled and the logic present is coupled from pin 14 to pins 11, 12, and 13 of gate IC202A. A high is inverted and used to turn on decimal point transistor Q220. When the segments of the appropriate LED are turned on, the decimal point segment is also turned on.

The decimal point of MSD (most significant digit) LED201 is physically inverted and used to indicate an overrange condition. Thus, when latch IC308A is selected by IC309, the information on pin 1 of IC332 is coupled to gate IC202A. The input pins of IC332 are sequentially sampled from pin 1 through pin 7 and pin 9 (pin 8 is a device ground).

Leading zero blanking is controlled by decimal point placement and the count stored in the latches. Prior to a display strobe cycle, strobe reset monostable IC320A and B generates a positive logic pulse. This pulse at pin 10 of IC332 forces pin 14 low. The positive reset pulse also forces pin 6 of gate IC202B low, through pins 3 and 4. Assume the count is zero in the MSD latch. With a zero count, pins 1, 2, 6, and 7 of IC201 are at a logic low. If a low is now applied to pin 5, pin 4 of IC201 is forced low. These lows are coupled to pins 1 and 8 of gate IC202C. With pin 2 already low, pin 9 of IC202C is forced high, holding pin 6 of IC202B low after completion of the strobe reset pulse. As long as pin 6 remains low, the display will remain blanked.

Two conditions can force IC201 to unblank. The first is caused by a decimal point or overrange condition at IC332. This will force pin 14 (IC332) high, pin 9 of gate IC202C low, and pin 6 of gate IC202B high (pins 3 and 4 are low). Pin 4 of IC201 is forced high, which insures that pin 5 will not go low until the next strobe reset pulse.

The second condition that forces IC201 to unblank occurs when a count other than zero is sensed at pins 1, 2, 6, and 7 of IC201. This forces pin 4 high and through gates IC202B and C, pin 5 (IC201) high. Pins 4 and 5 will remain high until the next strobe reset pulse.

In the events mode, prior to a count, all of the latches are at zero, no overrange condition exists, and there are no decimal points. To ensure this does not completely blank, pin 9 of IC332 is pulled high. Therefore, the LSD will always light regardless of count, but the decimal point is disconnected at LED208, so it will never light.

TIME BASE

Regulator IC346 supplies the precision +5 volts required to drive the 4 MHz TCXO (temperature compensated crystal oscillator). Dual-D flip-flop IC341 is wired as a divide-by-4 counter. The 1 MHz output is connected to pin 5 of gate IC342B. When Clock Select switch SW3 is in the Internal position, pins 1 and 2 of gate IC342A are grounded (low). This forces pin 4 of IC342B high and lets the 1 MHz signal couple through to pin 9 of gate IC342C. The low on pin 13 of gate IC342D forces pin 10 of IC342C high and lets the 1 MHz signal couple through to pin 8 of IC342C.

When an external time base is used, the internal time base is blocked at pin 5 of gate IC342B, by the low on pin 4. The externally applied time base is coupled through pin 12 of gate IC342D to pin 10 of gate IC342C, because of the high on pin 13. With pin 4 of gate IC342B low, pin 9 of gate IC342C is forced high and the externally applied time base signal is coupled through to pin 8 of IC342C. Zener diode ZD319 protects the input of gate IC342D by limiting external signal levels between +4.5 volts and approximately −0.6 volts.

Input Selector switch SW202 applies ground to pins 1 and 2 of gate IC330A, and pin 4 of gate IC330B when the 110 MHz input amplifiers are selected. Counter IC331 is wired to divide the time base by four. The high on pin 4 lets the signal couple through to pin 9 of IC330C. The high on pins 1 and 2 of IC330A forces pin 13 of IC330D low, which forces pin 10 of IC330C high and lets the time base (250 kHz internal) couple to pin 8 of gate IC330C. When either the 110 MHz or 250 MHz input is selected, the undivided time base (1 MHz internal) is coupled through gates IC330D and IC330C.

The time base at pin 8 of gate IC330C is divided by divide-by-10 counters IC326, IC327, IC328, and IC329. Time Base switch SW301 selects the time base rate and couples the signal to gate IC325B.

When the internal time base is selected by switch SW3, transistors Q305 and Q306 couple the 1 MHz signal to jack J4. Q305 and Q306 are wired to form a 50-ohm output drive for the time base signal.

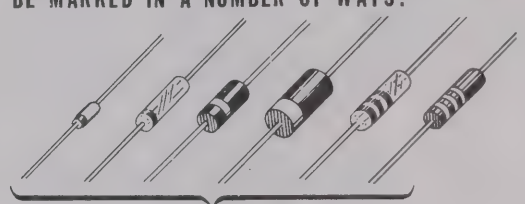
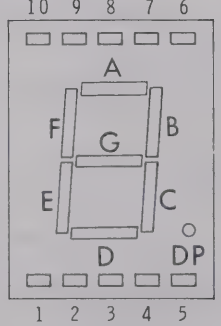
POWER SUPPLY

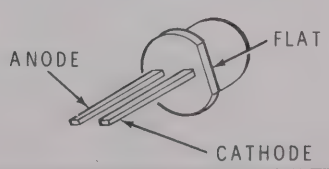
When the line cord is connected to a power source (line voltage), transformer T1 reduces the line voltage to the low levels required by the counter. The voltage at the red secondary winding is used by the optional DC power converter. The voltage at the green secondary winding is rectified by diodes D314, D315, D316, and D317, and filtered by capacitors C337 and C338. When power switch SW2 is closed, the positive DC voltage from diodes D315 and D317 is coupled to +5 volt regulators IC343 and IC345, while the negative DC voltage from diodes D314 and D316 is coupled to −5.2 volt regulator IC344. The capacitors on the output of each regulator supply additional filtering at various locations in the Counter.

J-K flip-flop IC340 is clocked at an 80 kHz rate by strobe timer IC333, and produces two 40 kHz output signals 180° out of phase. This chops the +5 and −5.2 volt signals, from regulators IC343 anf IC344, at transformer T301. T301 transforms the chopped DC to a 15-volt output that is rectified by diodes D310, D311, D312, and D313, and filtered by capacitors C322 and C323 to produce ±15-volt supplies. Resistors R355 through R360, and capacitors C325 and C326 provide the necessary feedback for proper chopper operation.

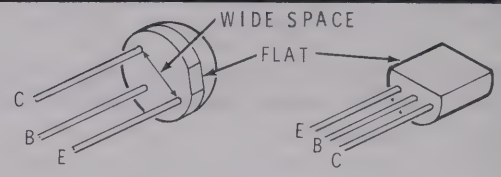
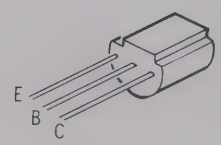
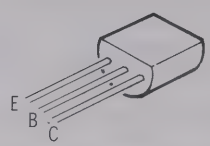
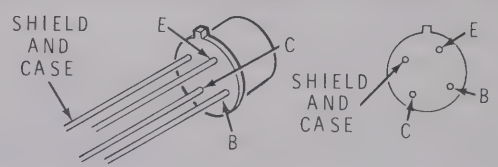
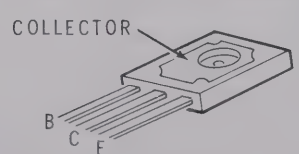
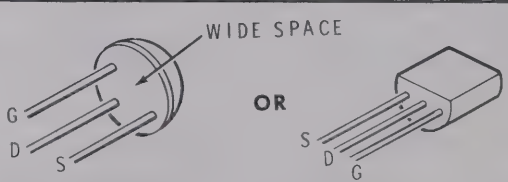
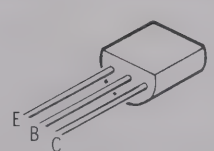
SEMICONDUCTOR IDENTIFICATION CHARTS

DIODES

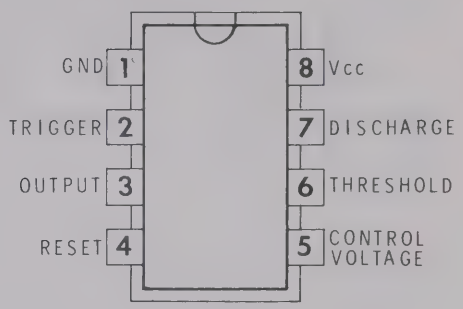
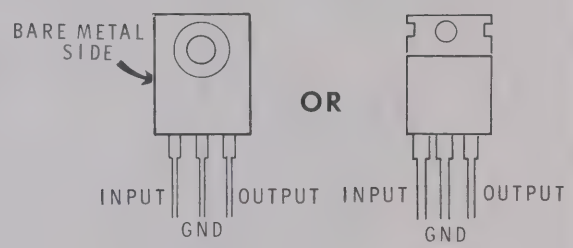
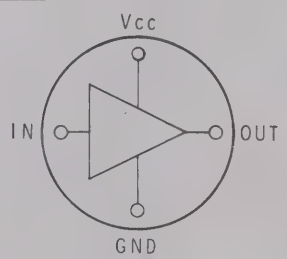
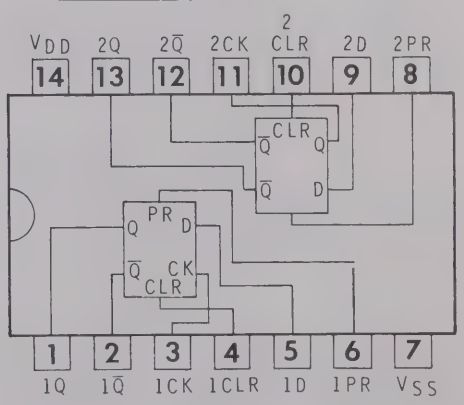
<table>
<tr><th>COMPONENT</th><th>HEATH PART NUMBER</th><th>MAY BE REPLACED WITH</th><th>IDENTIFICATION</th></tr>
<tr><td>D201, D202</td><td>56-86</td><td>FD777</td><td rowspan="8">IMPORTANT: THE BANDED END OF DIODES CAN BE MARKED IN A NUMBER OF WAYS.
 
BANDED END</td></tr>
<tr><td>D306, D307</td><td>56-26</td><td>1N191</td></tr>
<tr><td>D314, D315, D316, D317</td><td>57-42</td><td>3A1</td></tr>
<tr><td>ZD319</td><td>56-59</td><td>1N750A</td></tr>
<tr><td>D203</td><td>56-61</td><td>GESTB-620</td></tr>
<tr><td>D301, D302, D303, D304, D305, D308, D309, D310, D311, D312, D313</td><td>56-56</td><td>1N4149</td></tr>
<tr><td>ZD105, ZD204</td><td>56-67</td><td>VR-10A</td></tr>
<tr><td>D101, D102</td><td>56-87</td><td>FH1100</td></tr>
<tr><td>LED 201, LED 202, LED 203, LED 204, LED 205, LED 206, LED 207, LED 208</td><td>411-819</td><td>FND500</td><td>TOP VIEW
 

PIN
1.....Segment E
2.....Segment D
3.....Common Cathode
4.....Segment C
5.....DP
6.....Segment B
7.....Segment A
8.....Common Cathode
9.....Segment F
10.....Segment G</td></tr>
<tr><td>LED 209</td><td>412-616</td><td>FLV117</td><td> 
</td></tr>
</table>

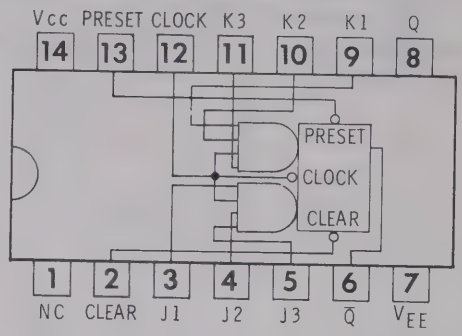
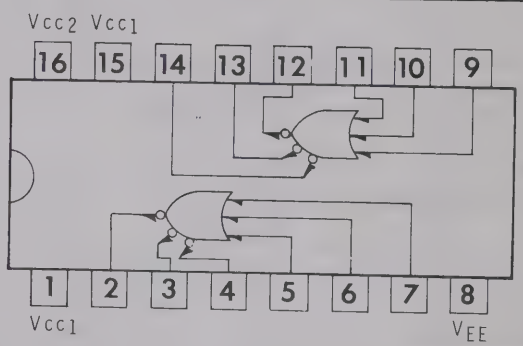
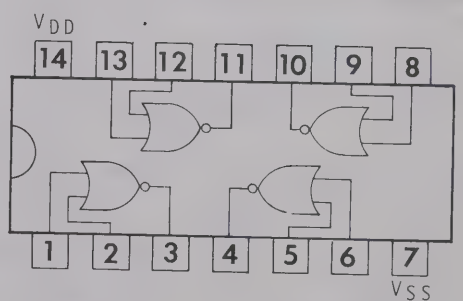
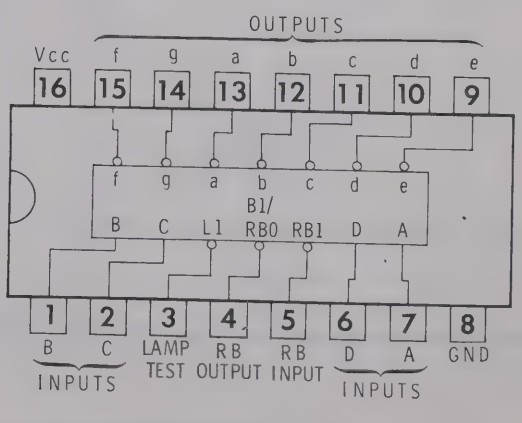
TRANSISTORS

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
Q201, Q202, Q203, Q204, Q205, Q206, Q207, Q306	417-235	2N4121	
Q301	417-293	2N5770	
Q302, Q303, Q304, Q305	417-801	MPSA20	
Q219	417-813	2N4959	
Q101, Q102, Q103, Q104	417-839	2N5179	
Q307, Q308	417-819	MJE171	
Q218	417-828	E-304 SELECTED	
Q208, Q209, Q210, Q211, Q212, Q213, Q214, Q215, Q216	417-881	MPSA13	
Q220	417-885	MPSA65	

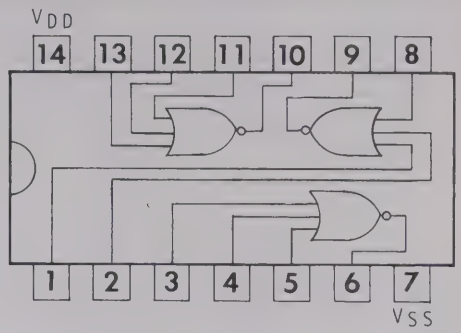
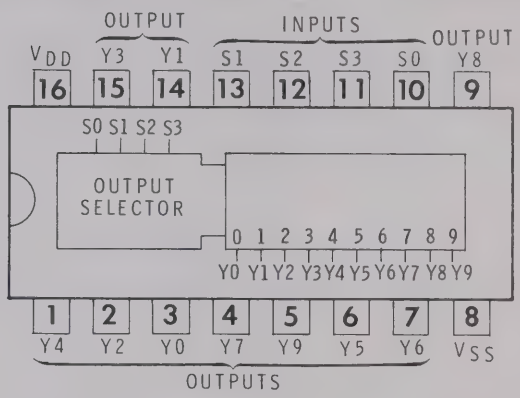
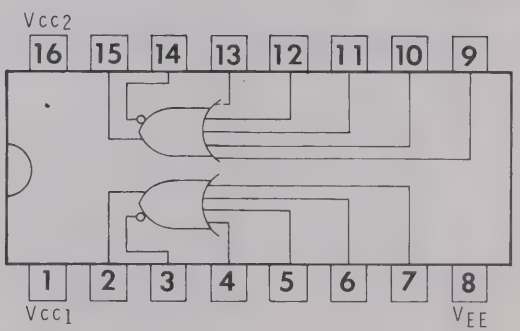
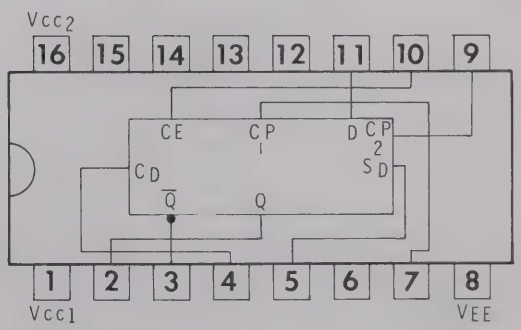
INTEGRATED CIRCUITS

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION TOP VIEW (EXCEPT 443-644)
IC333	442-53	NE555V	
IC343, IC345, IC346	442-54	UA7805	
IC344	442-630	MC7905	
IC103	442-628	GPD401	
IC101, IC102	442-629	GPD402	
IC319	443-607	CD4013AE	

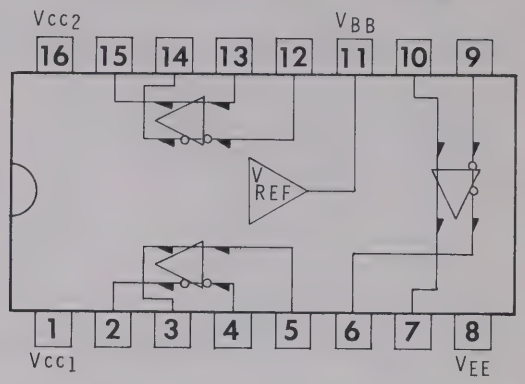
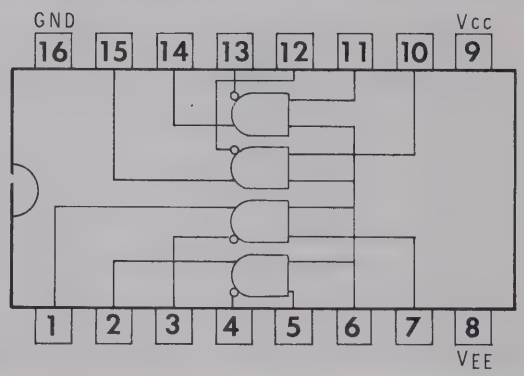
Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC340	443-4	SN7472	
IC302, IC303, IC312	443-677	MC10211	
IC318	443-695	CD4001	
IC201	443-711	74LS247	

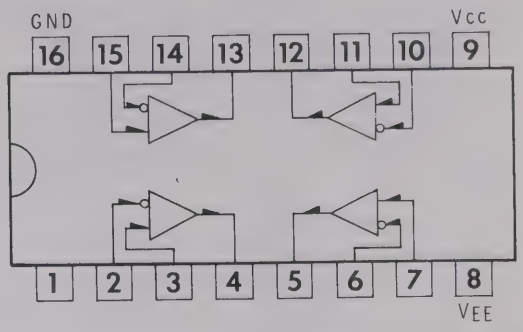
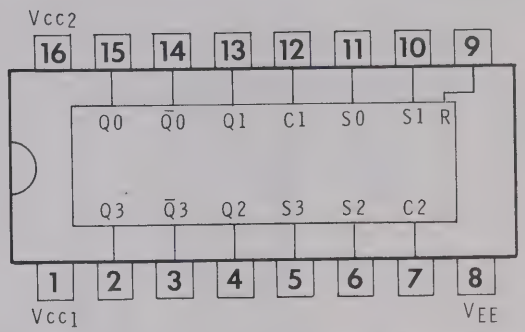
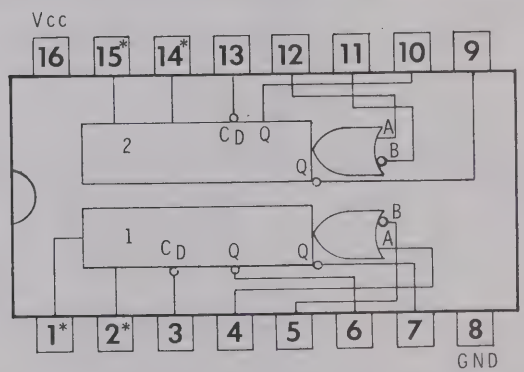
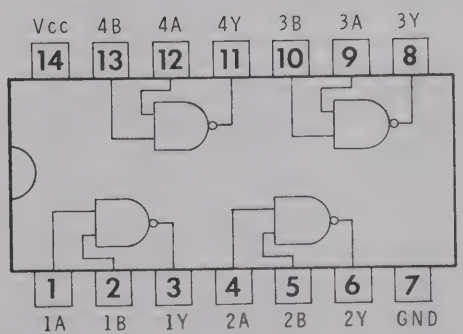
Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC202, IC320	443-712	MC14025	
IC203	443-713	MC14028	
IC105	443-714	11C01	
IC106	443-715	UA11C70	

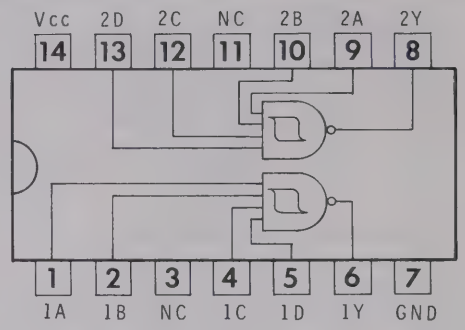
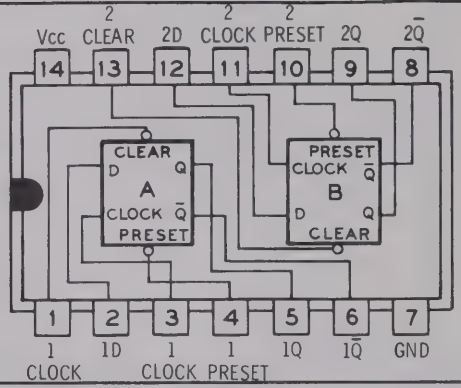
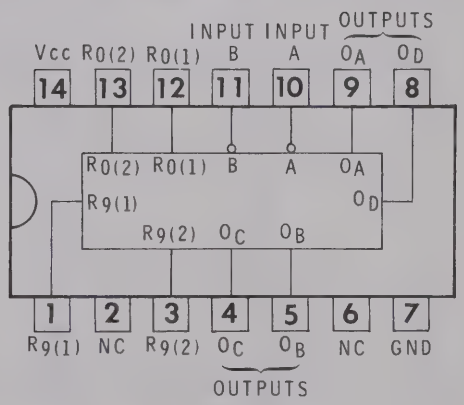
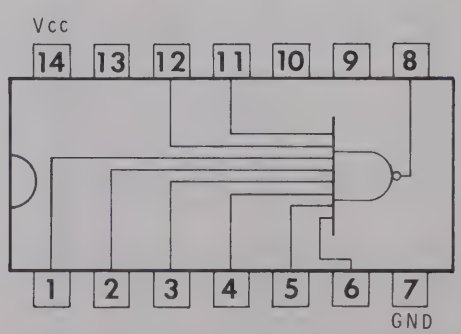
Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC301	443-723	MC10216	
IC310	443-724	MC10124	

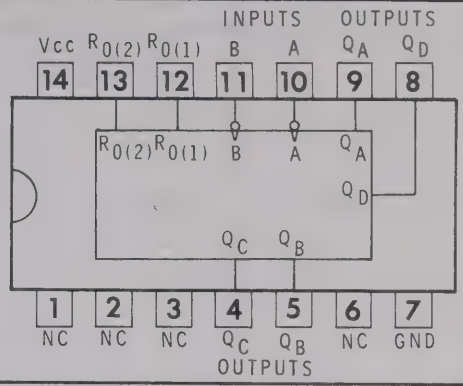
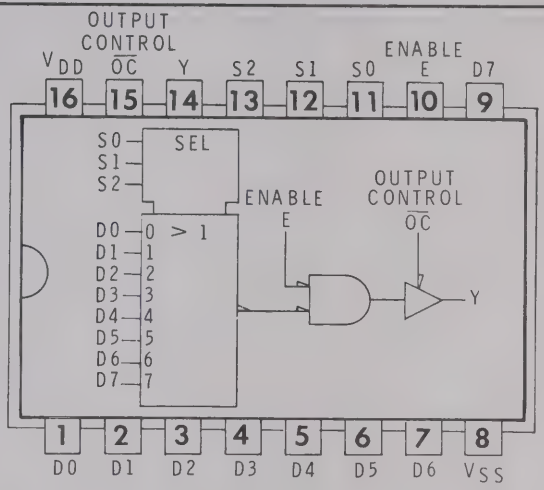
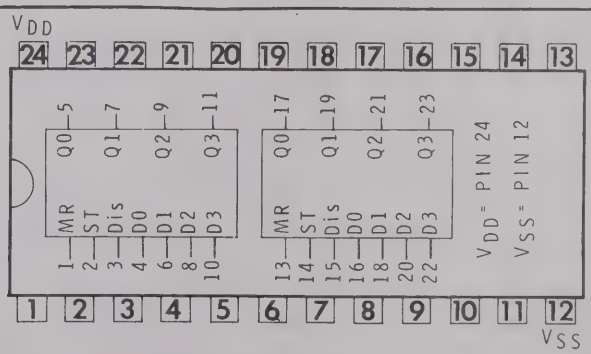
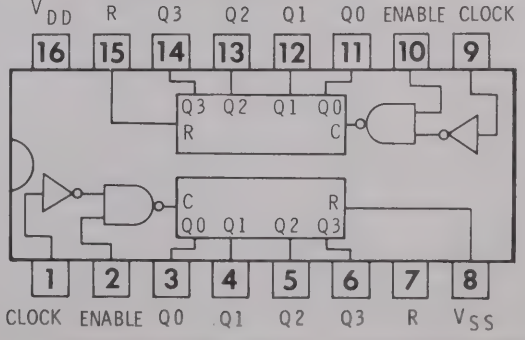
Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC304	443-725	MC10125	
IC311	443-726	MC10138	
IC339	443-727	96L02	
IC322, IC324, IC325, IC330, IC342	443-728	SN74LS00	

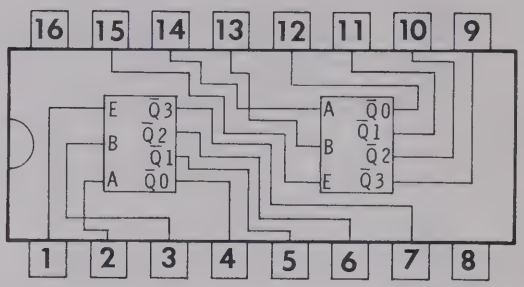
Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC338	443-729	SN74LS13	
IC323 IC341	443-730	SN74LS74	 Vcc 2 CLEAR 2D 2 CLOCK 2 PRESET 2Q 2Q̄ 14 13 12 11 10 9 8 CLEAR D Q A CLOCK Q̄ PRESET PRESET CLOCK Q̄ B D Q CLEAR 1 2 3 4 5 6 7 1 CLOCK 1D 1 CLOCK 1 PRESET 1Q 1Q̄ GND
IC313, IC314, IC315, IC326, IC327, IC328, IC329, IC335, IC336, IC337	443-731	SN74LS290	
IC334	443-732	SN74LS30	

Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC331	443-733	SN74LS293	
IC332	443-735	MC14512	 OUTPUT CONTROL ENABLE V_{DD} $\overline{OC}$ Y S2 S1 S0 E D7 16 15 14 13 12 11 10 9 S0 S1 S2 SEL ENABLE E OUTPUT CONTROL $\overline{OC}$ D0 D1 D2 D3 D4 D5 D6 D7 0 1 2 3 4 5 6 7 V > 1 Y 1 2 3 4 5 6 7 8 D0 D1 D2 D3 D4 D5 D6 V_{SS}
IC305, IC306, IC307, IC308	443-736	MC14508	
IC316, IC317, IC321	443-737	MC14518	

Integrated Circuits (cont'd.)

COMPONENT	HEATH PART NUMBER	MAY BE REPLACED WITH	IDENTIFICATION
IC309	443-738	MC14556	

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $_____
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUT ALONG DOTTED LINE

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $_____
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

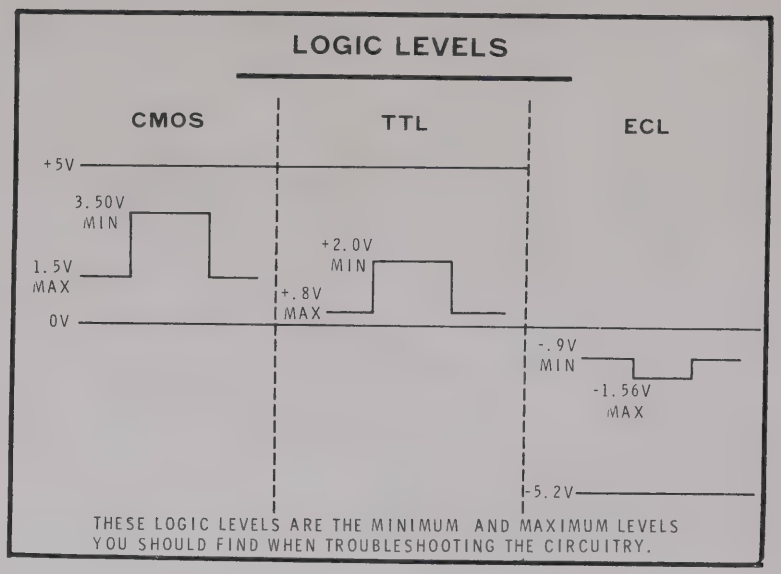
C OF THE
KIT®
/ SM-4120
IIOD METER

THIS SYMBOL INDICATES A CONNECTION TO A VOLTAGE SOURCE.

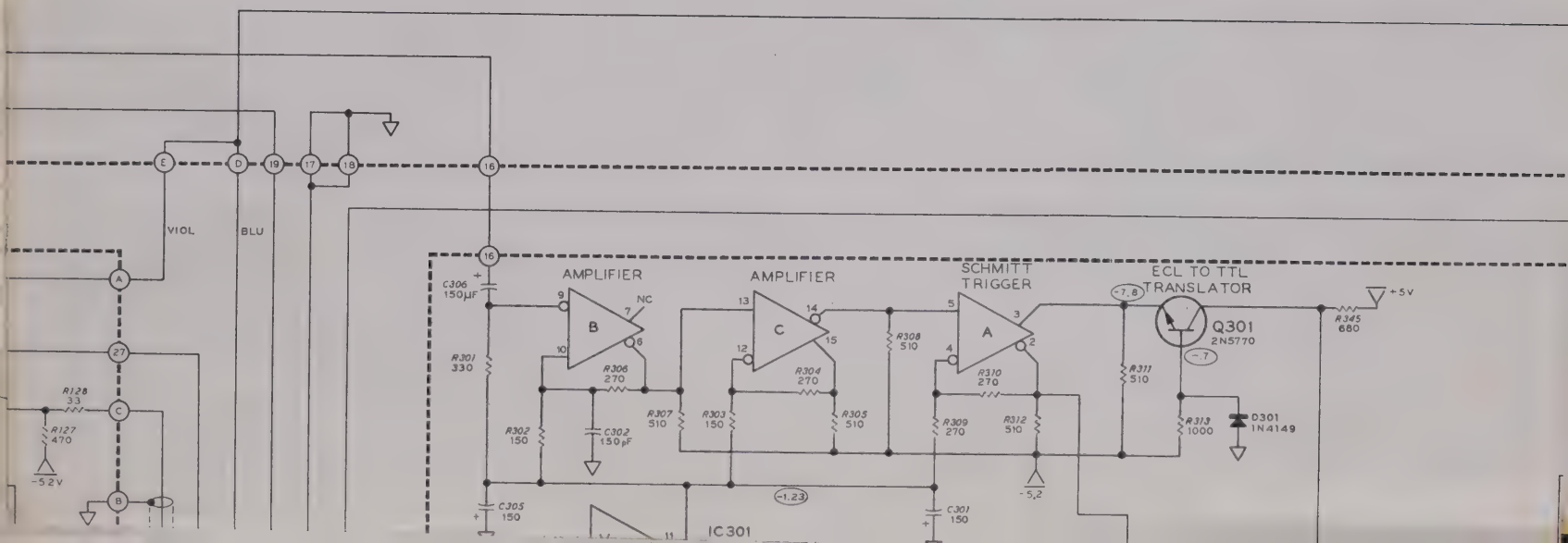
THIS SYMBOL INDICATES A TEST POINT.

ARROW INDICATES CLOCKWISE ROTATION.

- ALL RESISTORS ARE 1/4-WATT, 5% UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1000, M=1,000,000).
- ALL CAPACITORS ARE IN µF (MICROFARADS) UNLESS MARKED OTHERWISE.
- PARTS IN SHADED AREAS ARE CRITICAL FOR CONTINUED SAFETY. REPLACE THEM ONLY WITH PARTS OF THE SAME RATING OR WITH THE PROPER HEATH PARTS.
- IC PINS NOT SHOWN, ARE NOT CONNECTED IN THE CIRCUITS.



AY CIRCUIT BOARD



FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $_____
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

CUT ALONG DOTTED LINE

FOR PARTS REQUESTS ONLY

- Be sure to follow instructions carefully.
- Use a separate letter for all correspondence.
- Please allow 10 - 14 days for mail delivery time.

DO NOT WRITE IN THIS SPACE

INSTRUCTIONS

- Please print all information requested.
- Be sure you list the correct **HEATH** part number exactly as it appears in the parts list.
- If you wish to prepay your order, mail this card and your payment in an envelope. Be sure to include 10% (25¢ minimum, $3.50 maximum) for insurance, shipping and handling. Michigan residents add 4% tax.

  Total enclosed $_____
- If you prefer COD shipment, check the COD box and mail this form. COD ☐

NAME _____

ADDRESS _____

CITY _____

STATE _____ ZIP _____

The information requested in the next two lines is not required when purchasing nonwarranty replacement parts, but it can help us provide you with better products in the future.

Model # _____ Invoice # _____

Date Purchased _____ Location Purchased _____

LIST **HEATH** PART NUMBER	QTY.	PRICE EACH	TOTAL PRICE
TOTAL FOR PARTS			
HANDLING AND SHIPPING			
MICHIGAN RESIDENTS ADD 4% TAX			
TOTAL AMOUNT OF ORDER			

SEND TO: **HEATH COMPANY**
BENTON HARBOR
MICHIGAN 49022
ATTN: PARTS REPLACEMENT

Phone (Replacement parts only): 616 982-3571

THIS FORM IS FOR U.S. CUSTOMERS ONLY
OVERSEAS CUSTOMERS SEE YOUR DISTRIBUTOR

SCHEMATIC OF THE HEATHKIT®

MODEL IM-4120 / SM-4120

FREQUENCY/PERIOD METER

Copyright © 1977
Heath Company
All Rights Reserved
Printed in the United States of America

Part of 595-1917-01

NOTES:

1. COMPONENTS ARE NUMBERED IN THE FOLLOWING GROUPS:
   - 1 - 99 MOUNTED ON CHASSIS.
   - 101-199 MOUNTED ON INPUT CIRCUIT BOARD.
   - 201-299 MOUNTED ON DISPLAY CIRCUIT BOARD.
   - 301-399 MOUNTED ON MAIN CIRCUIT BOARD.
2. ▽ THIS SYMBOL INDICATES A CIRCUIT BOARD GROUND.
3. ⏚ THIS SYMBOL INDICATES CHASSIS GROUND.
4. ○ THIS SYMBOL WITH A LETTER INDICATES A CIRCUIT BOARD WIRE CONNECTION. THIS SYMBOL WITH A NUMBER INDICATES A CIRCUIT BOARD-TO-CIRCUIT BOARD "F-PIN" CONNECTION.
5. ⬭ THIS SYMBOL INDICATES A DC VOLTAGE MEASUREMENT TAKEN WITH A HIGH-IMPEDANCE INPUT VOLTMETER FROM THE POINT INDICATED TO CIRCUIT GROUND. SWITCHES IN POSITION SHOWN.
6. ▽ THIS SYMBOL INDICATES A CONNECTION TO A VOLTAGE SOURCE.
7. ⬡ THIS SYMBOL INDICATES A TEST POINT.
8. ARROW INDICATES CLOCKWISE ROTATION.
9. ALL RESISTORS ARE 1/4-WATT, 5% UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1000, M=1,000,000).
10. ALL CAPACITORS ARE IN µF (MICROFARADS) UNLESS MARKED OTHERWISE.
11. PARTS IN SHADED AREAS ARE CRITICAL FOR CONTINUED SAFETY. REPLACE THEM ONLY WITH PARTS OF THE SAME RATING OR WITH THE PROPER HEATH PARTS.
12. IC PINS NOT SHOWN, ARE NOT CONNECTED IN THE CIRCUITS.

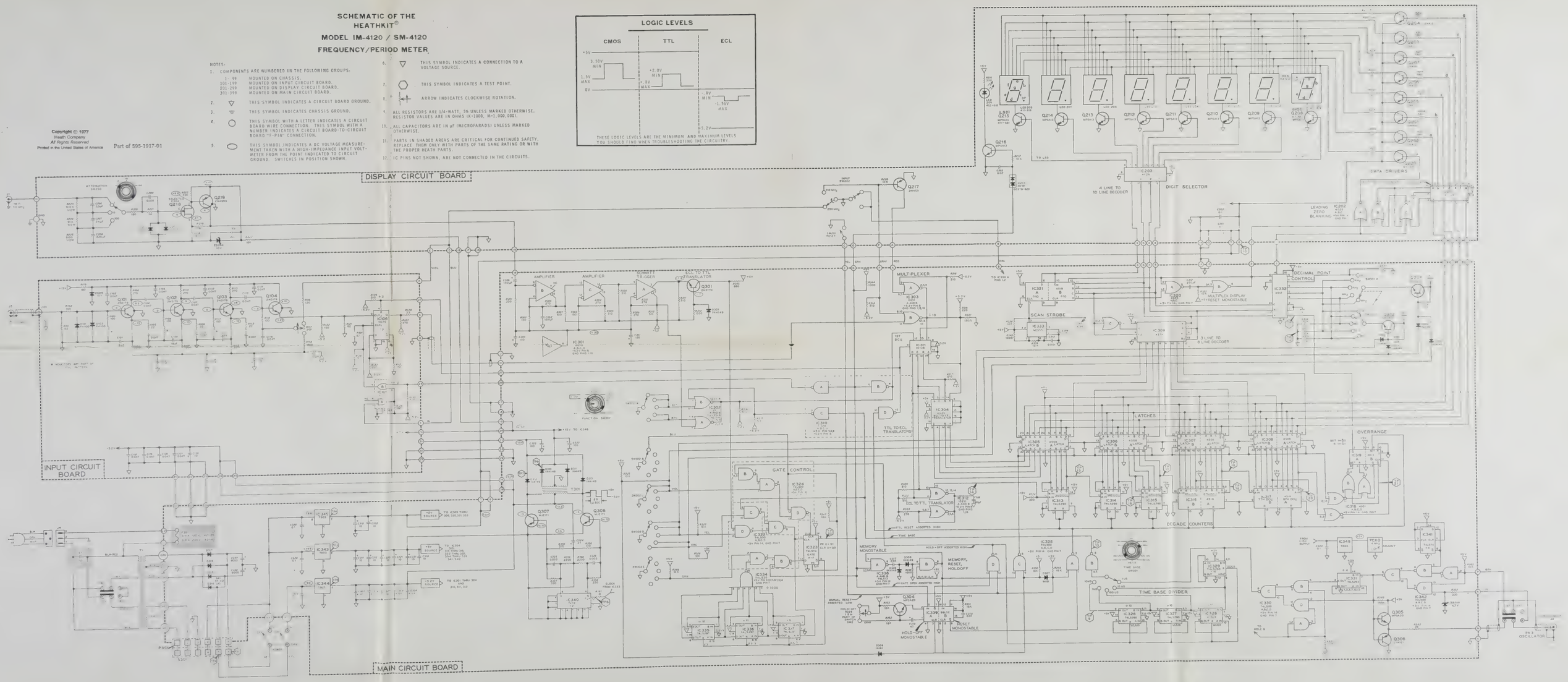
LOGIC LEVELS

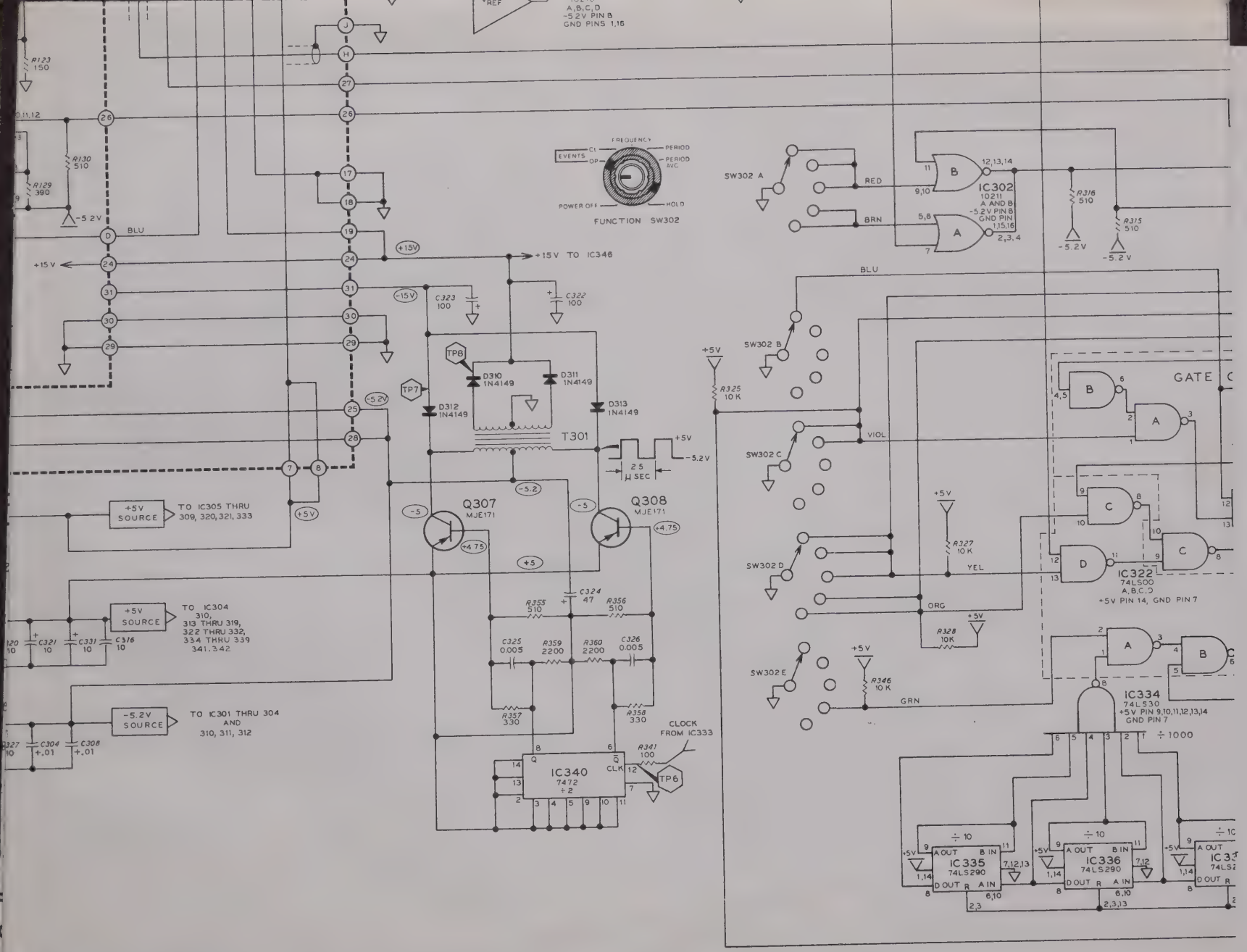
THESE LOGIC LEVELS ARE THE MINIMUM AND MAXIMUM LEVELS YOU SHOULD FIND WHEN TROUBLESHOOTING THE CIRCUITRY.

DISPLAY CIRCUIT BOARD

INPUT CIRCUIT BOARD

MAIN CIRCUIT BOARD



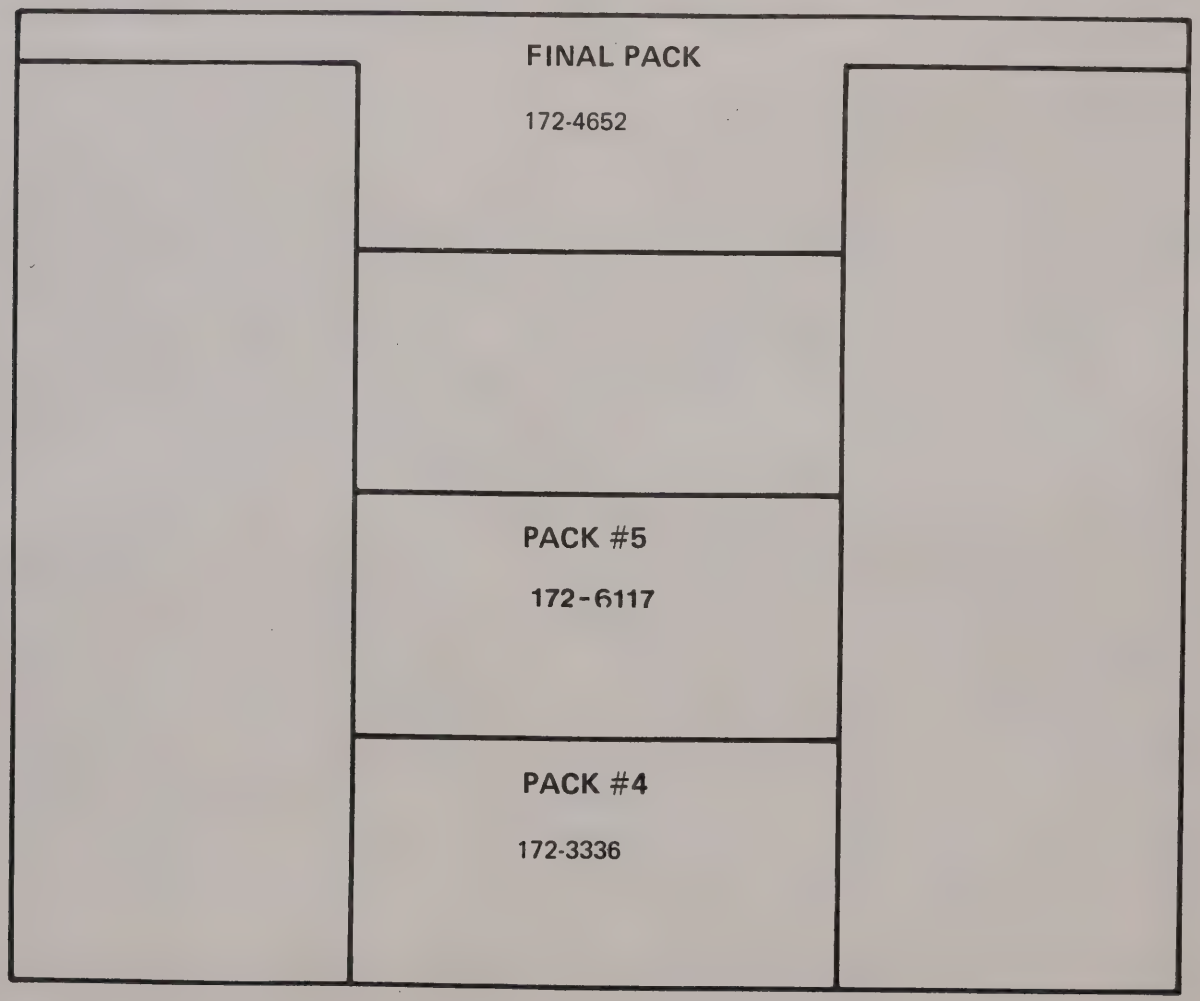


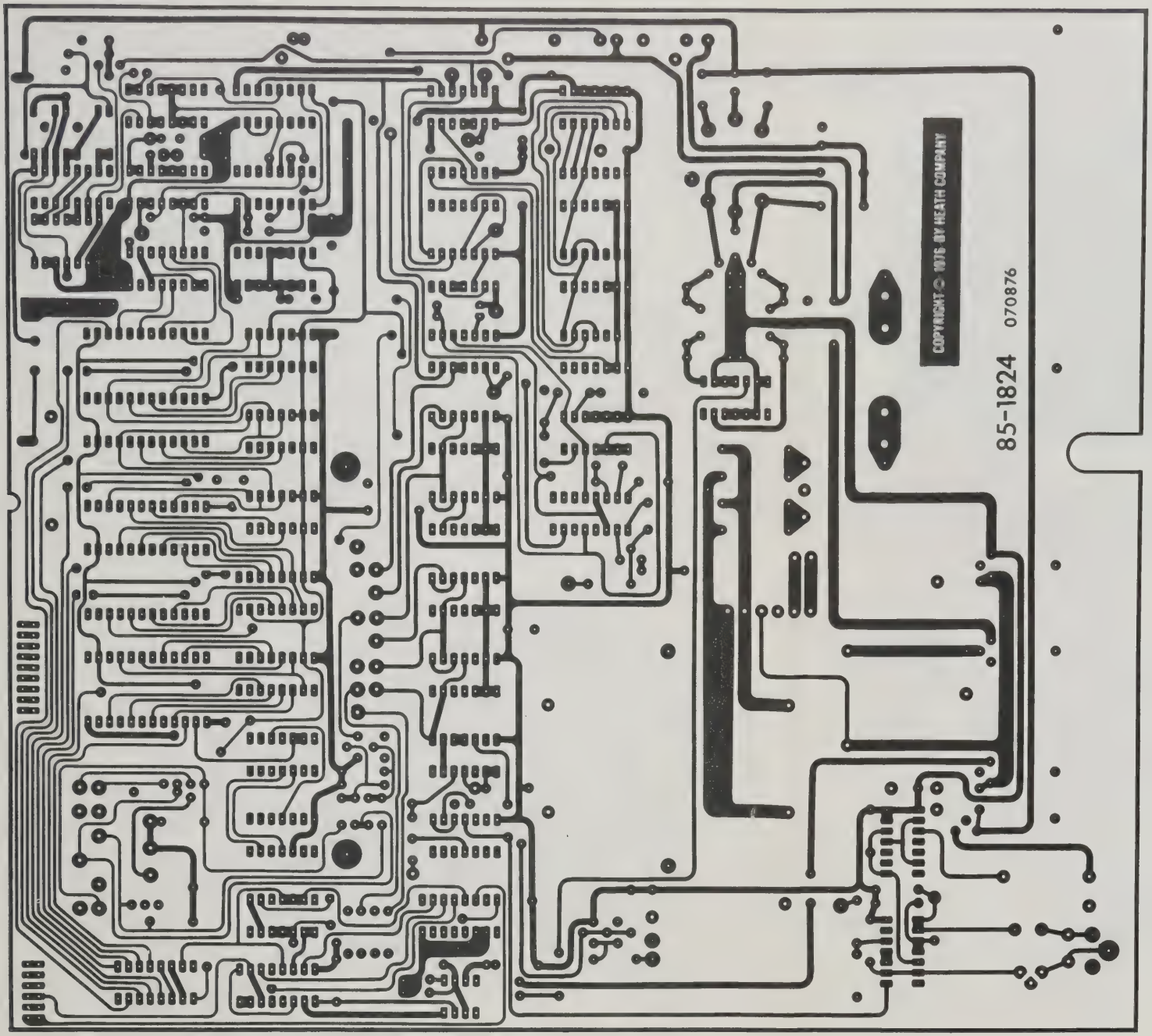
AIN CIRCUIT BOARD

PACK INDEX SHEET

Do NOT unpack . . . . . until the Manual calls for each **PACK** by number. Some of the 171 and/or 172-series numbers are shown to help you identify each **PACK** (the 171 and/or 172-series part numbers on bags and boxes may have more digits than shown).

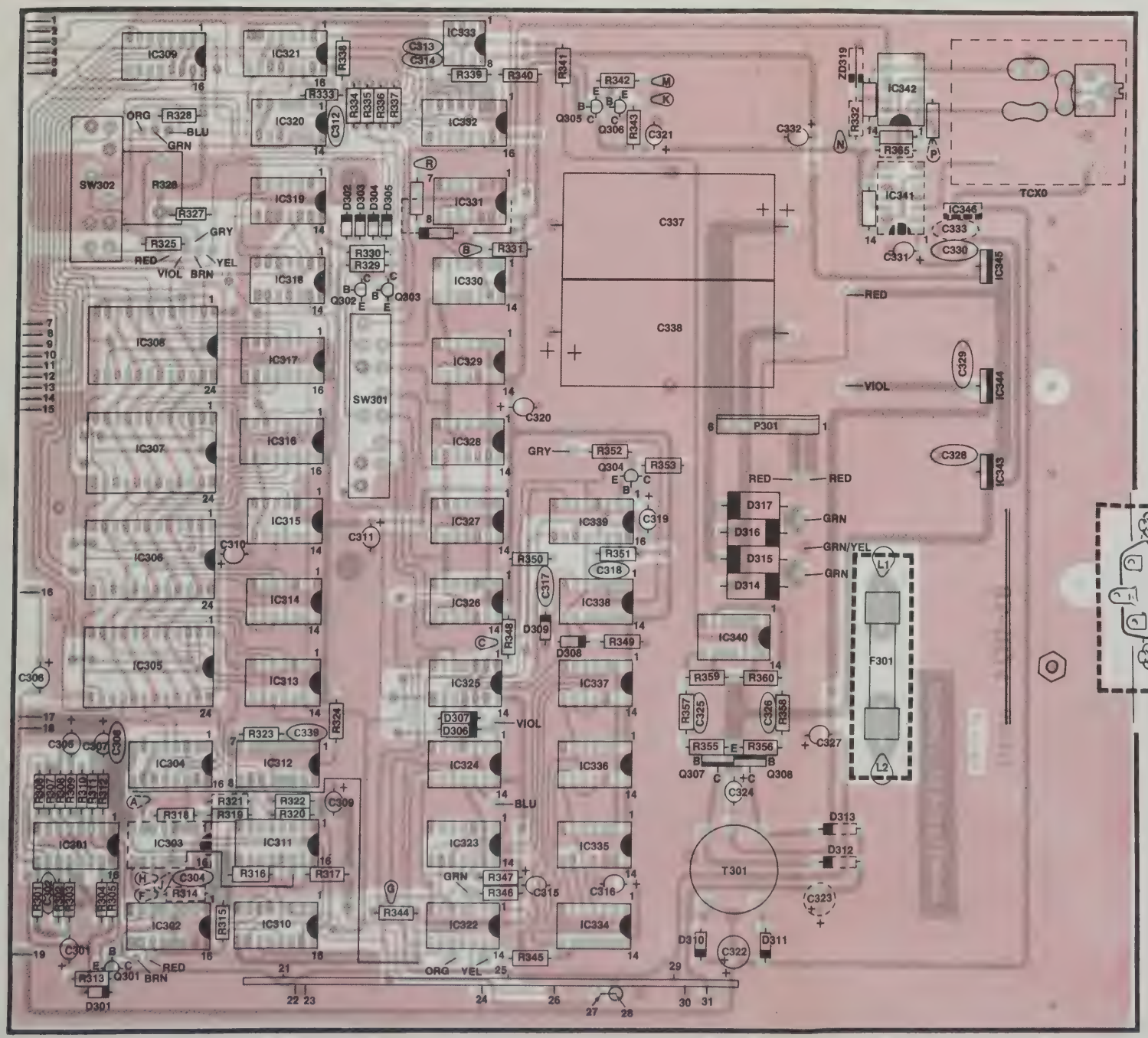
DO NOT USE 171 or 172-series numbers when ordering replacement parts.





MAIN CIRCUIT BOARD
(Shown from foil side)

MAIN CIRCUIT BOARD
(Viewed from Component side)



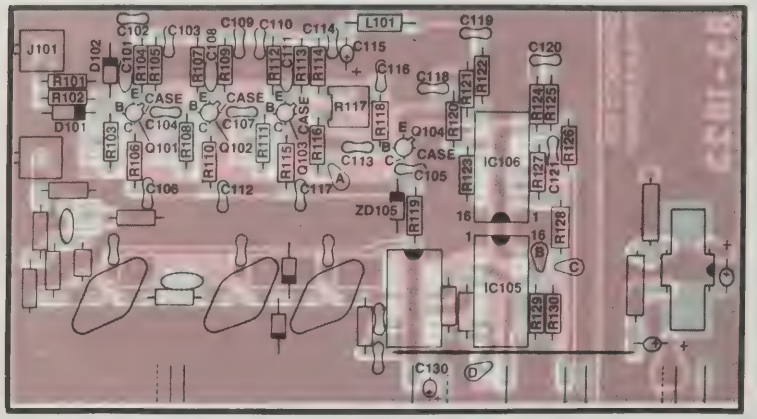
CIRCUIT BOARD X-RAY VIEWS

NOTE: To find the PART NUMBER of a component for the purpose of order a replacement part:

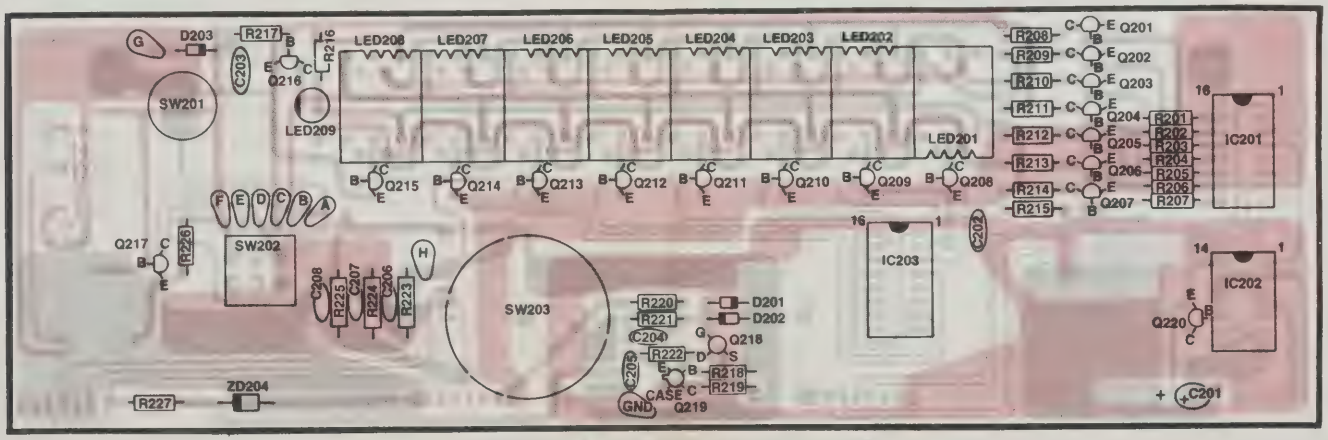
A. Find the circuit component number (R5, C3, etc.) on the X-Ray View.

B. Locate this same number in the "Circuit Component Number" column of the "Parts List" in the front of this Manual.

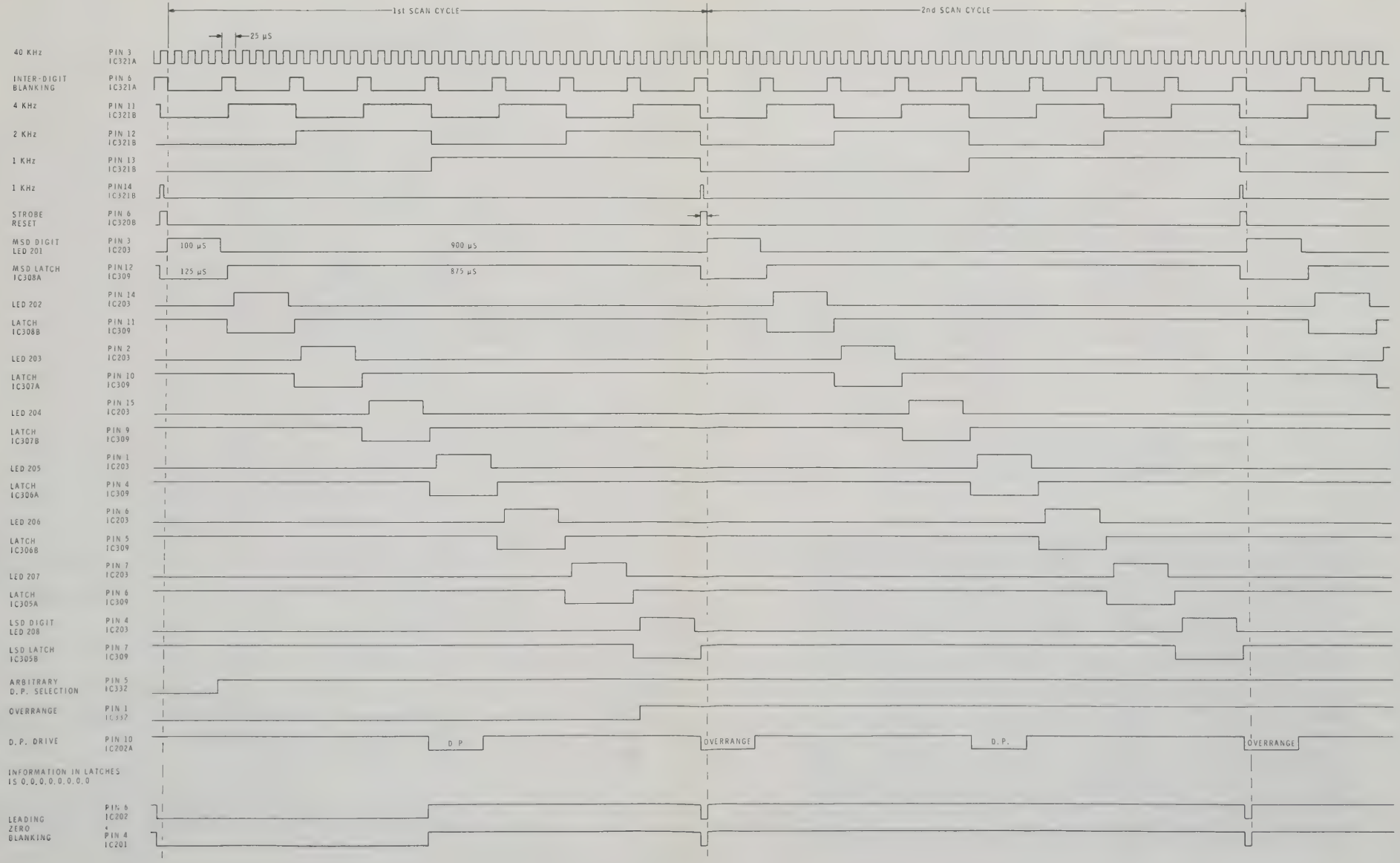
C. Adjacent to the circuit component number, you will find the PART NUMBER and DESCRIPTION which must be supplied when you order a replacement part.



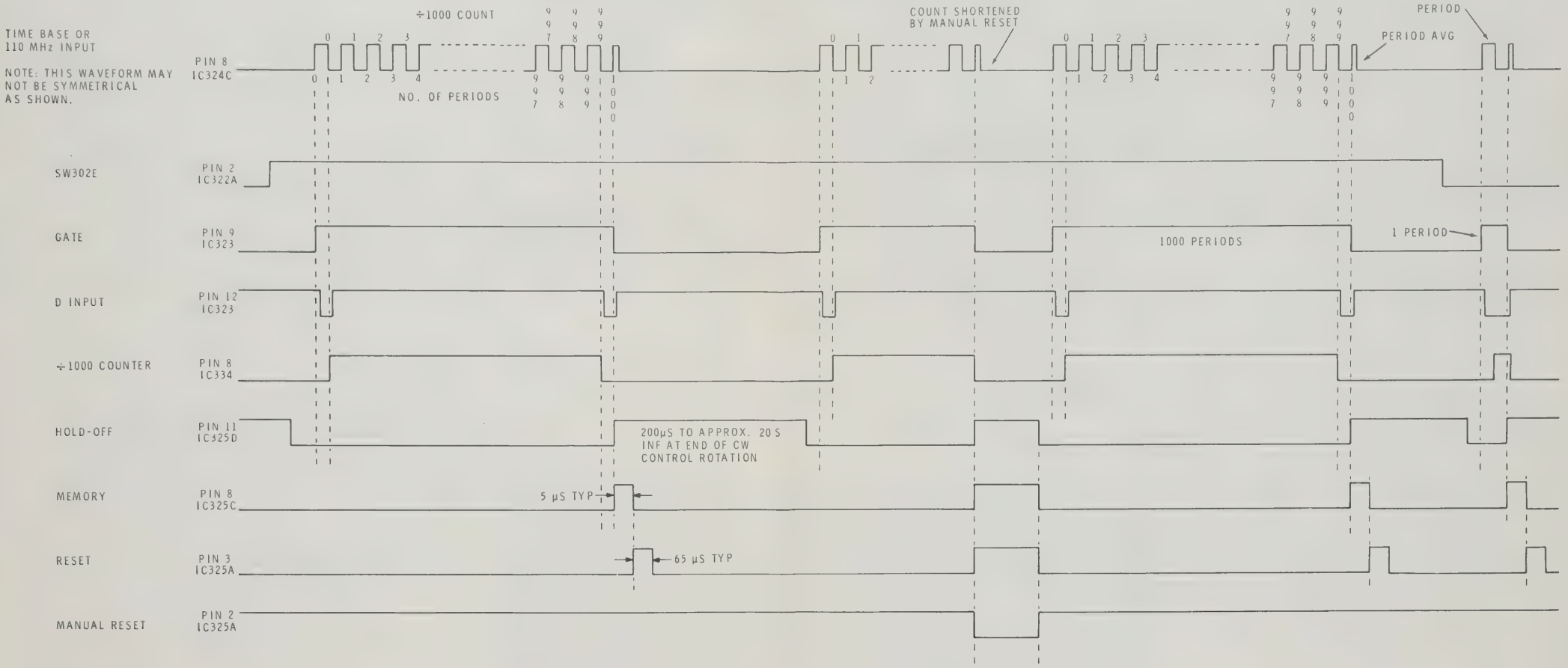
INPUT CIRCUIT BOARD
(Viewed from Component side)



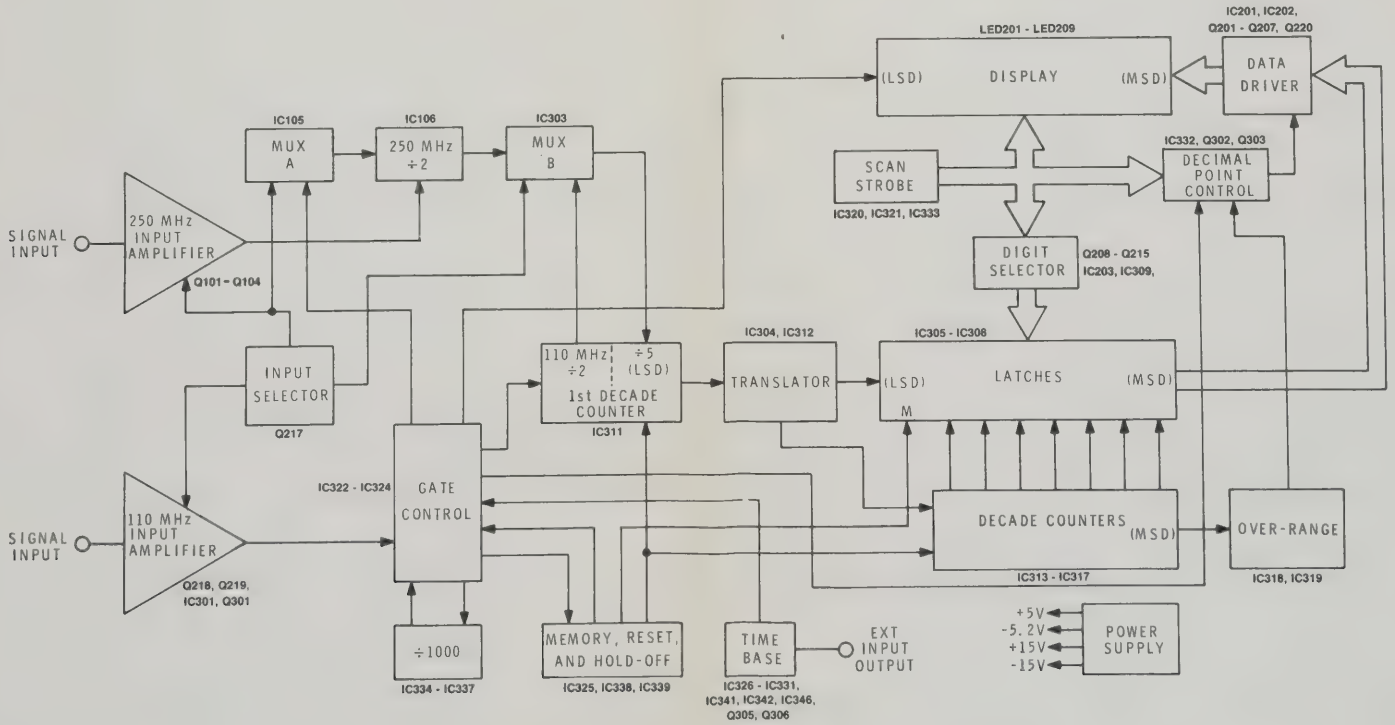
DISPLAY CIRCUIT BOARD
(Viewed from foil side)



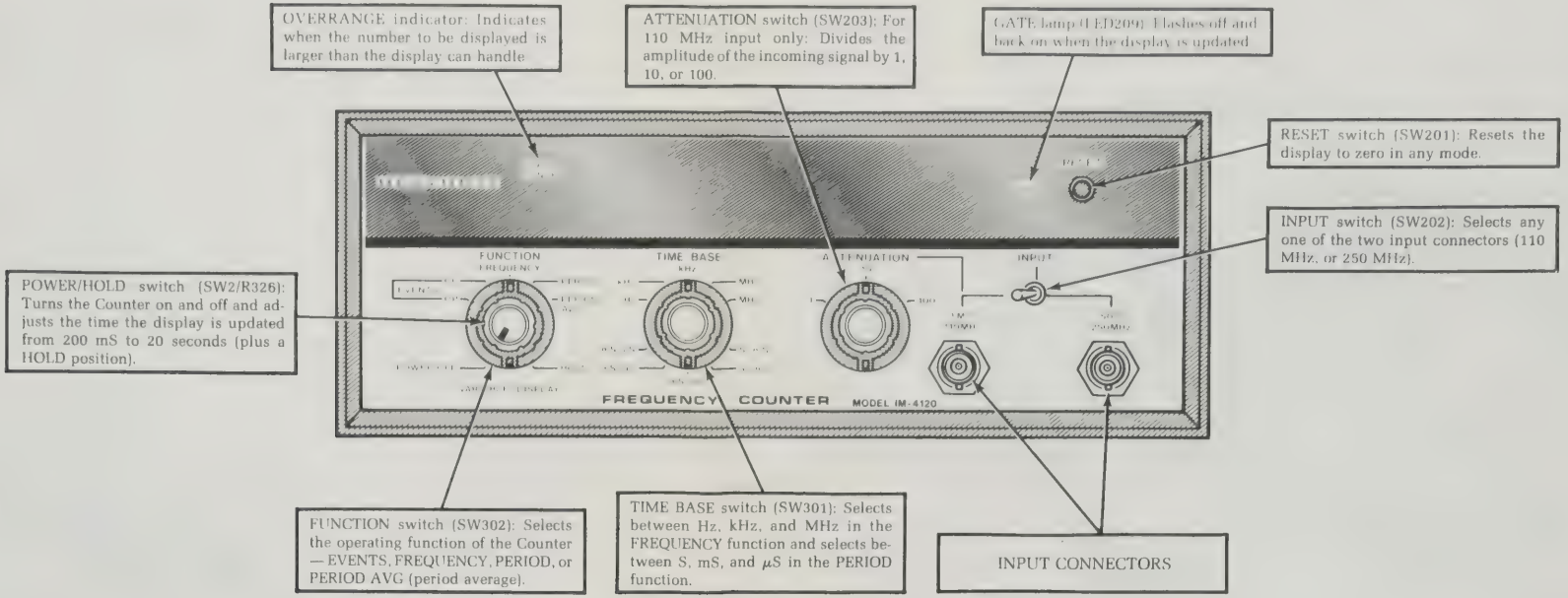
PICTORIAL 9-2



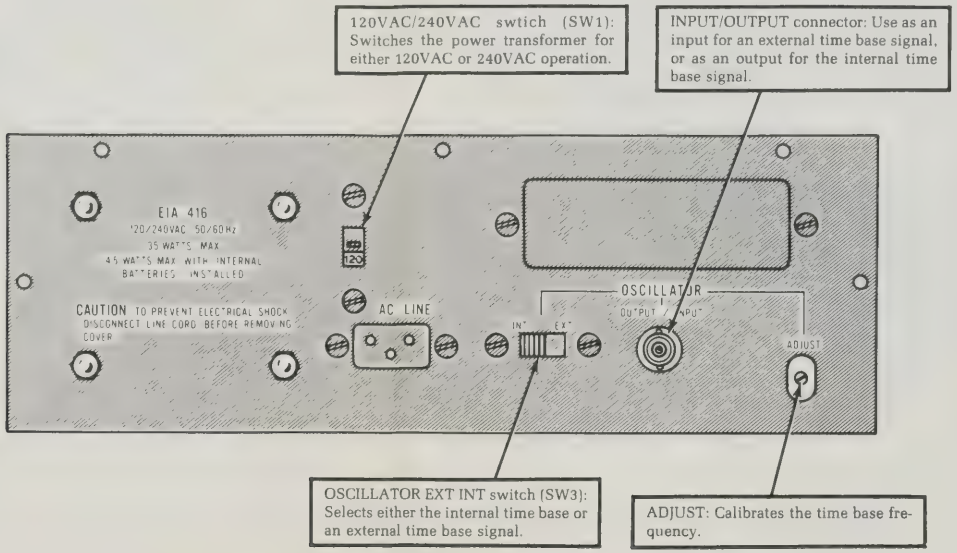
PICTORIAL 9-1

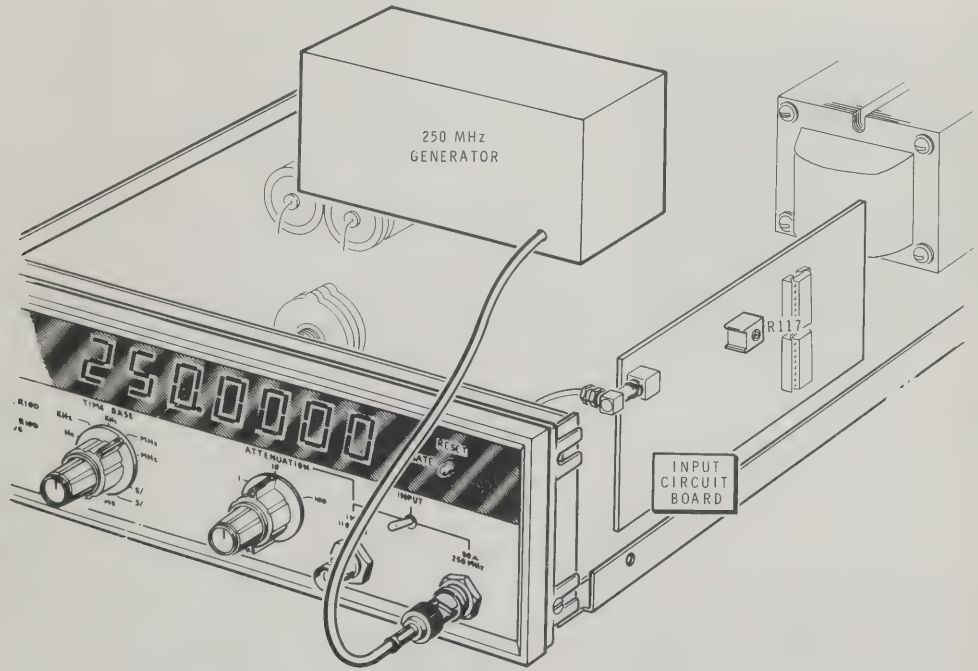


BLOCK DIAGRAM

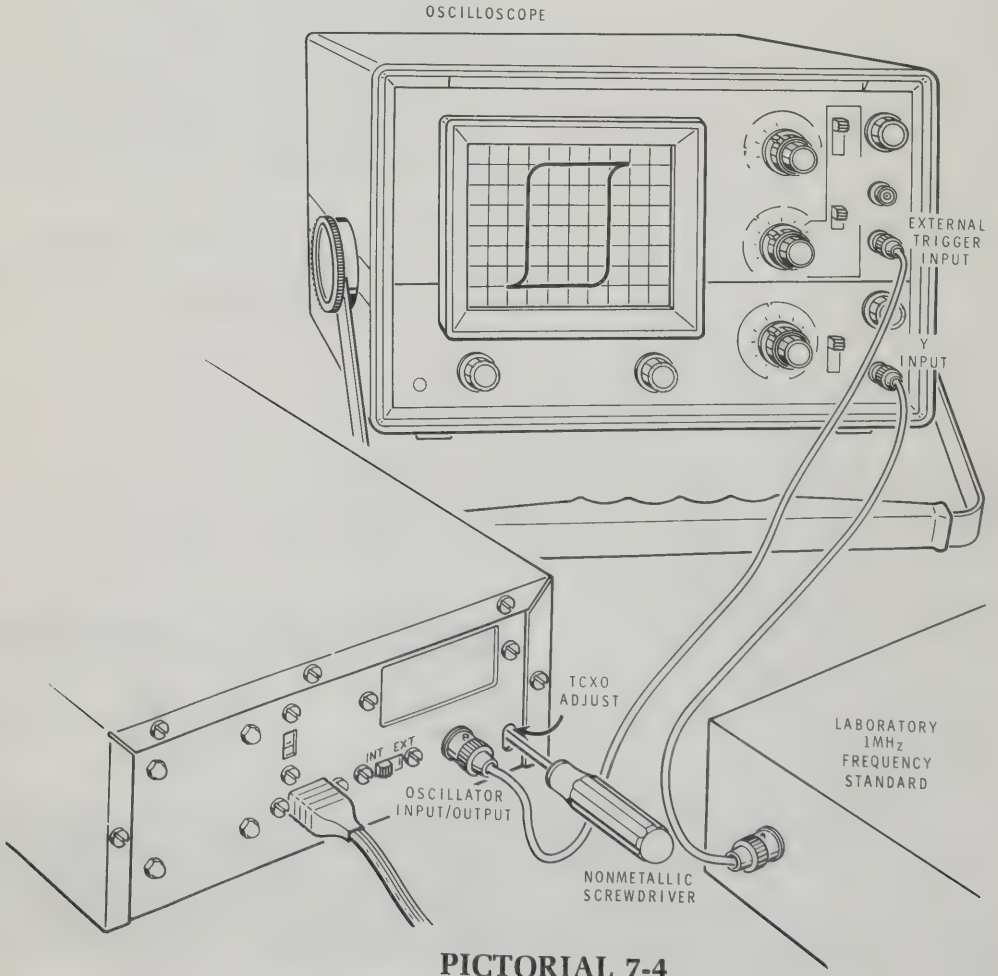

OVERRANGE indicator: Indicates when the number to be displayed is larger than the display can handle
ATTENUATION switch (SW203): For 110 MHz input only: Divides the amplitude of the incoming signal by 1, 10, or 100.
GATE lamp (LED209): Flashes off and back on when the display is updated
RESET switch (SW201): Resets the display to zero in any mode.
INPUT switch (SW202): Selects any one of the two input connectors (110 MHz, or 250 MHz).
POWER/HOLD switch (SW2/R326): Turns the Counter on and off and adjusts the time the display is updated from 200 mS to 20 seconds (plus a HOLD position).
FUNCTION
TIME BASE
ATTENUATION
INPUT
FREQUENCY COUNTER
MODEL IM-4120
FUNCTION switch (SW302): Selects the operating function of the Counter — EVENTS, FREQUENCY, PERIOD, or PERIOD AVG (period average).
TIME BASE switch (SW301): Selects between Hz, kHz, and MHz in the FREQUENCY function and selects between S, mS, and μS in the PERIOD function.
INPUT CONNECTORS

PICTORIAL 8-1

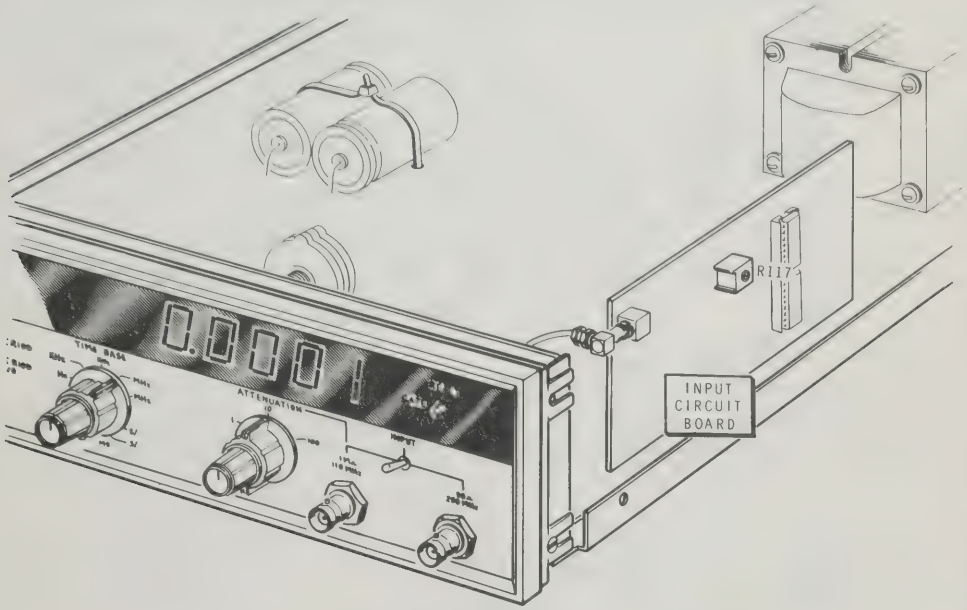

120VAC/240VAC swtich (SW1): Switches the power transformer for either 120VAC or 240VAC operation.
INPUT/OUTPUT connector: Use as an input for an external time base signal, or as an output for the internal time base signal.
EIA 416
120/240VAC 50/60Hz
35 WATTS MAX
45 WATTS MAX WITH INTERNAL BATTERIES INSTALLED
CAUTION TO PREVENT ELECTRICAL SHOCK DISCONNECT LINE CORD BEFORE REMOVING COVER
AC LINE
120
OSCILLATOR
IN
EXT
ADJUST
OSCILLATOR EXT INT switch (SW3): Selects either the internal time base or an external time base signal.
ADJUST: Calibrates the time base frequency.



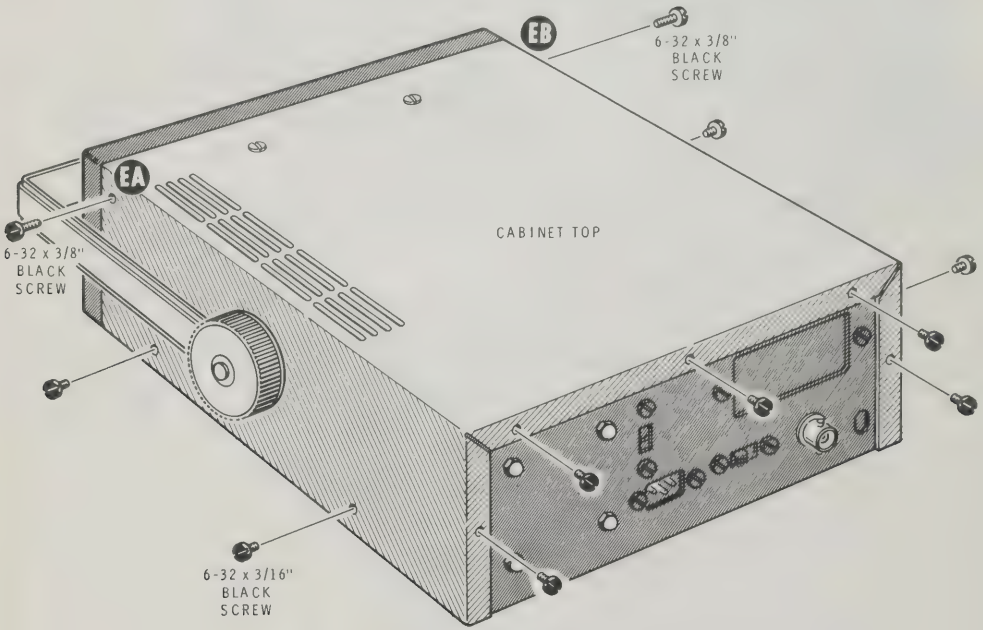
PICTORIAL 7-3



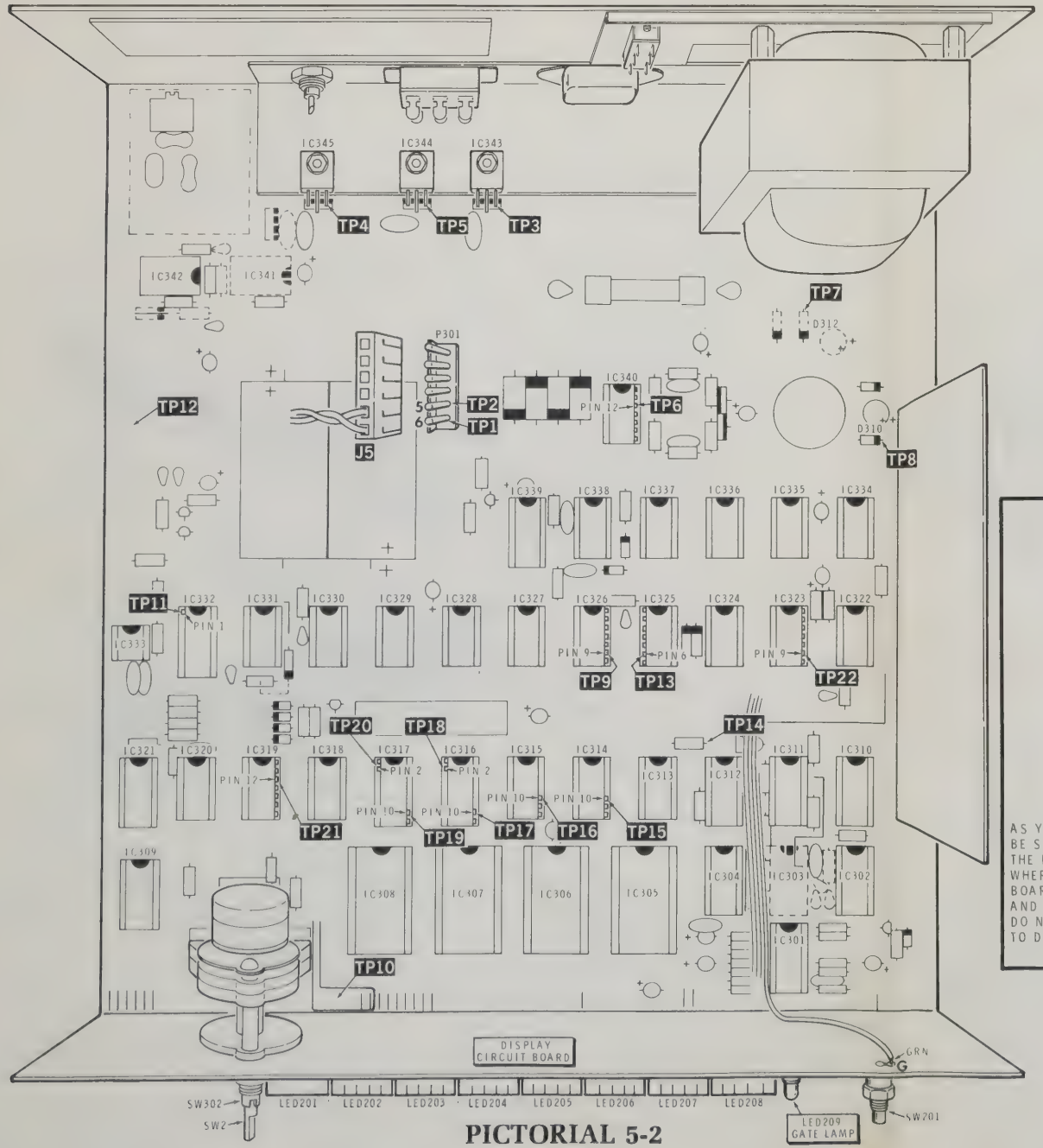
PICTORIAL 7-4



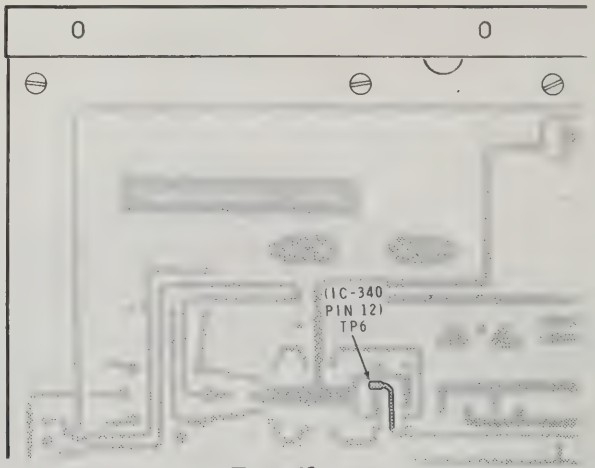
PICTORIAL 7-1



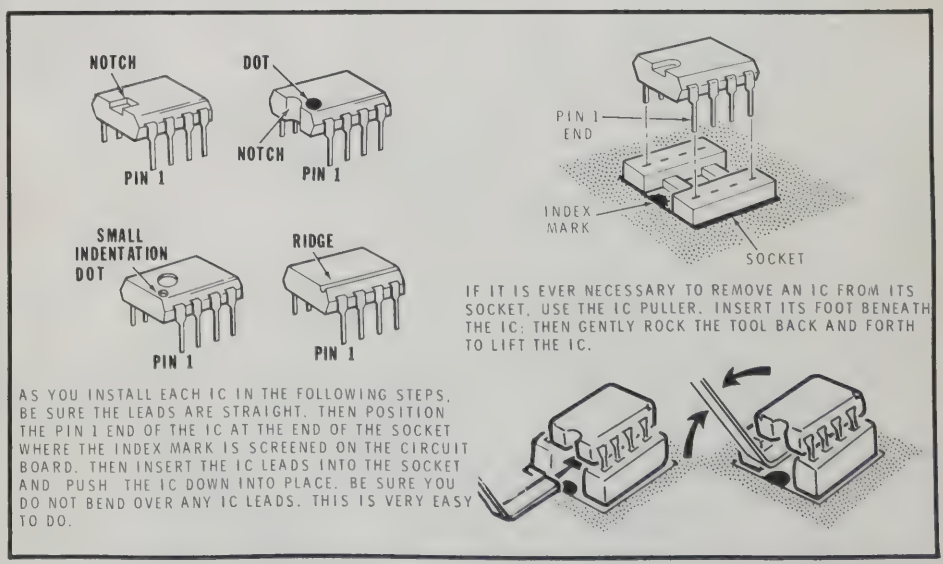
PICTORIAL 7-2



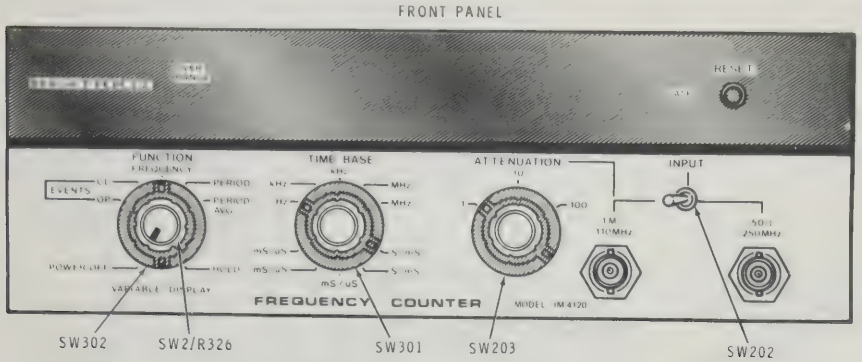
PICTORIAL 5-2



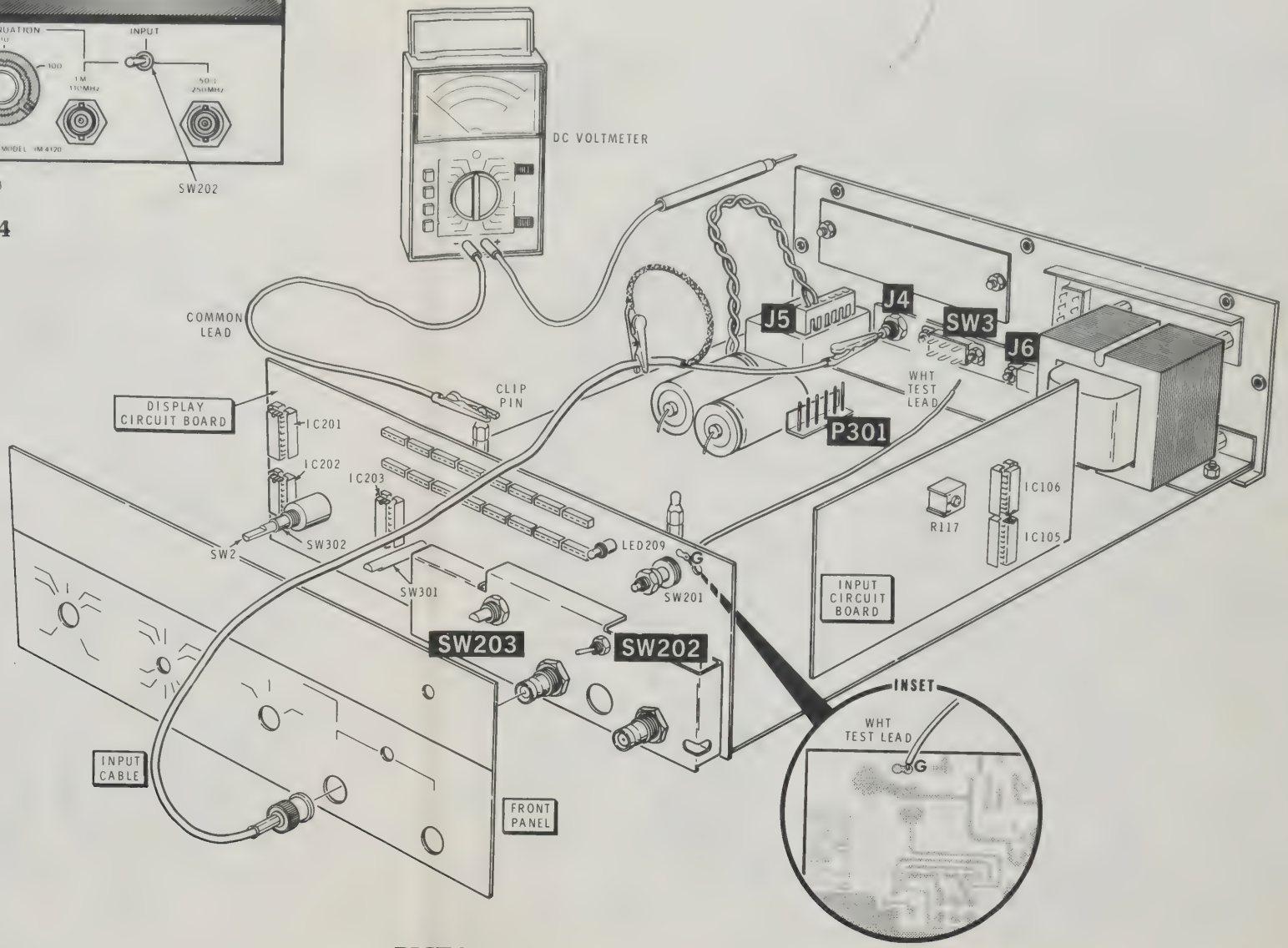
Detail 5-2B


NOTCH
PIN 1
DOT
NOTCH
PIN 1
SMALL INDENTATION DOT
PIN 1
RIDGE
PIN 1
PIN 1 END
INDEX MARK
SOCKET
IF IT IS EVER NECESSARY TO REMOVE AN IC FROM ITS SOCKET, USE THE IC PULLER. INSERT ITS FOOT BENEATH THE IC: THEN GENTLY ROCK THE TOOL BACK AND FORTH TO LIFT THE IC.
AS YOU INSTALL EACH IC IN THE FOLLOWING STEPS, BE SURE THE LEADS ARE STRAIGHT. THEN POSITION THE PIN 1 END OF THE IC AT THE END OF THE SOCKET WHERE THE INDEX MARK IS SCREENED ON THE CIRCUIT BOARD. THEN INSERT THE IC LEADS INTO THE SOCKET AND PUSH THE IC DOWN INTO PLACE. BE SURE YOU DO NOT BEND OVER ANY IC LEADS. THIS IS VERY EASY TO DO.

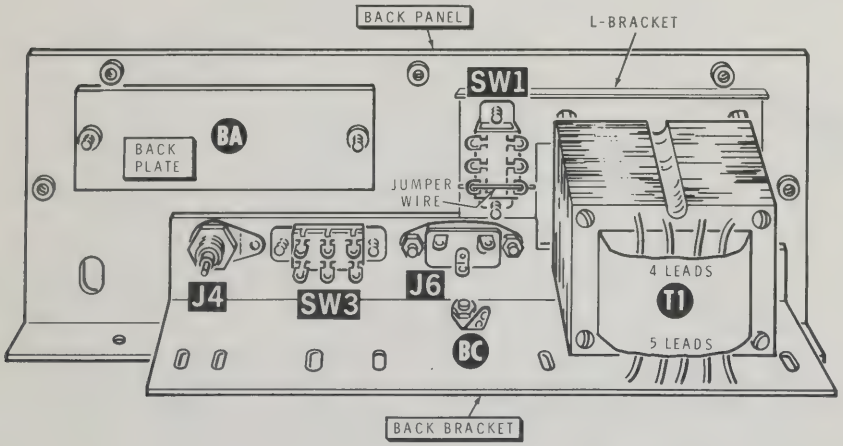
Detail 5-2A



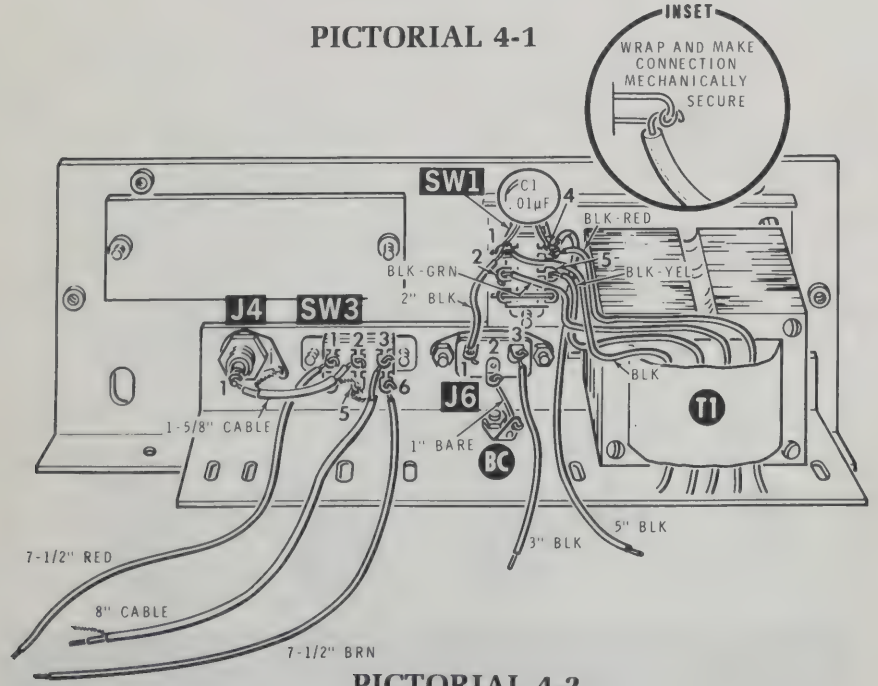
PICTORIAL 4-4



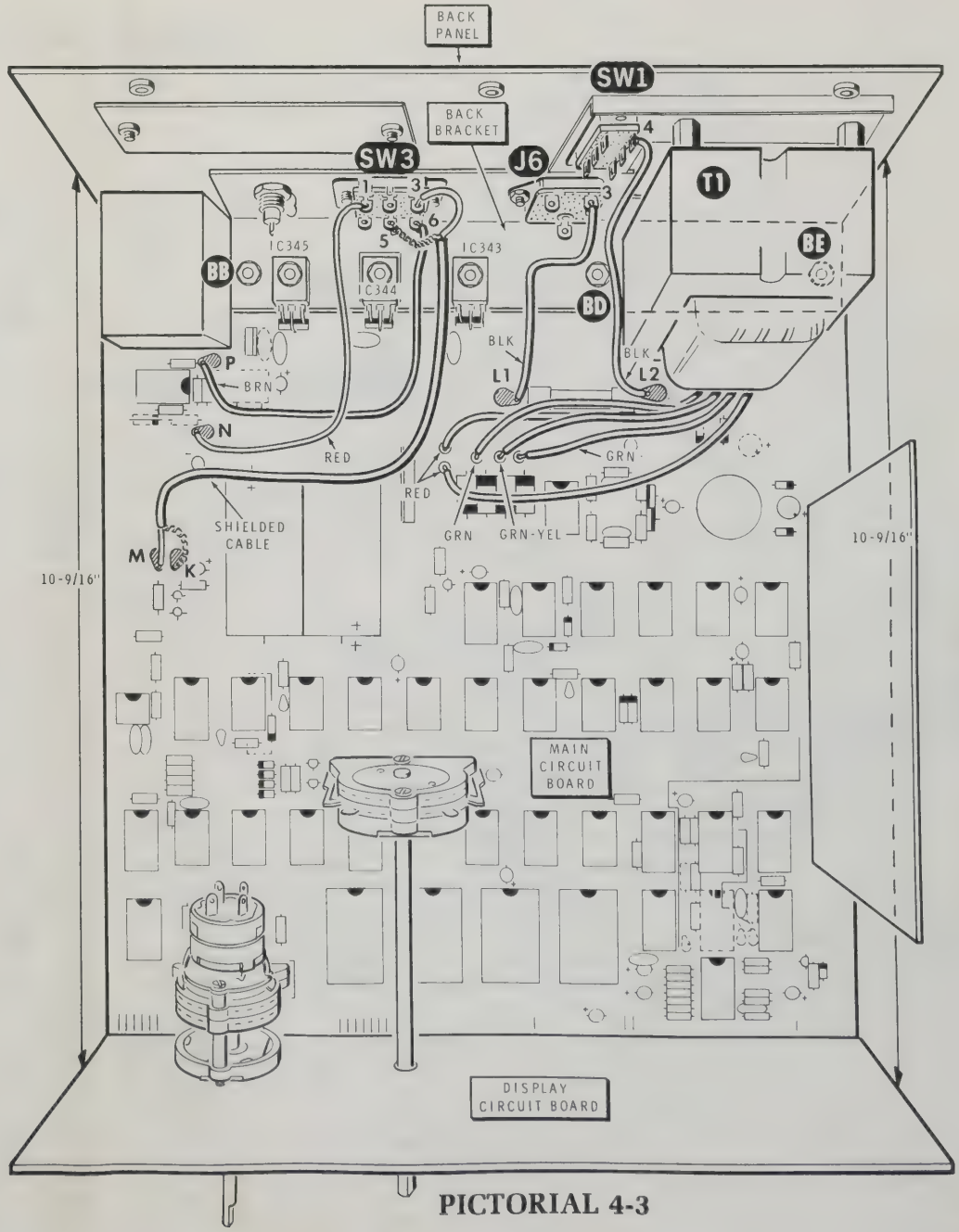
PICTORIAL 5-1



PICTORIAL 4-1

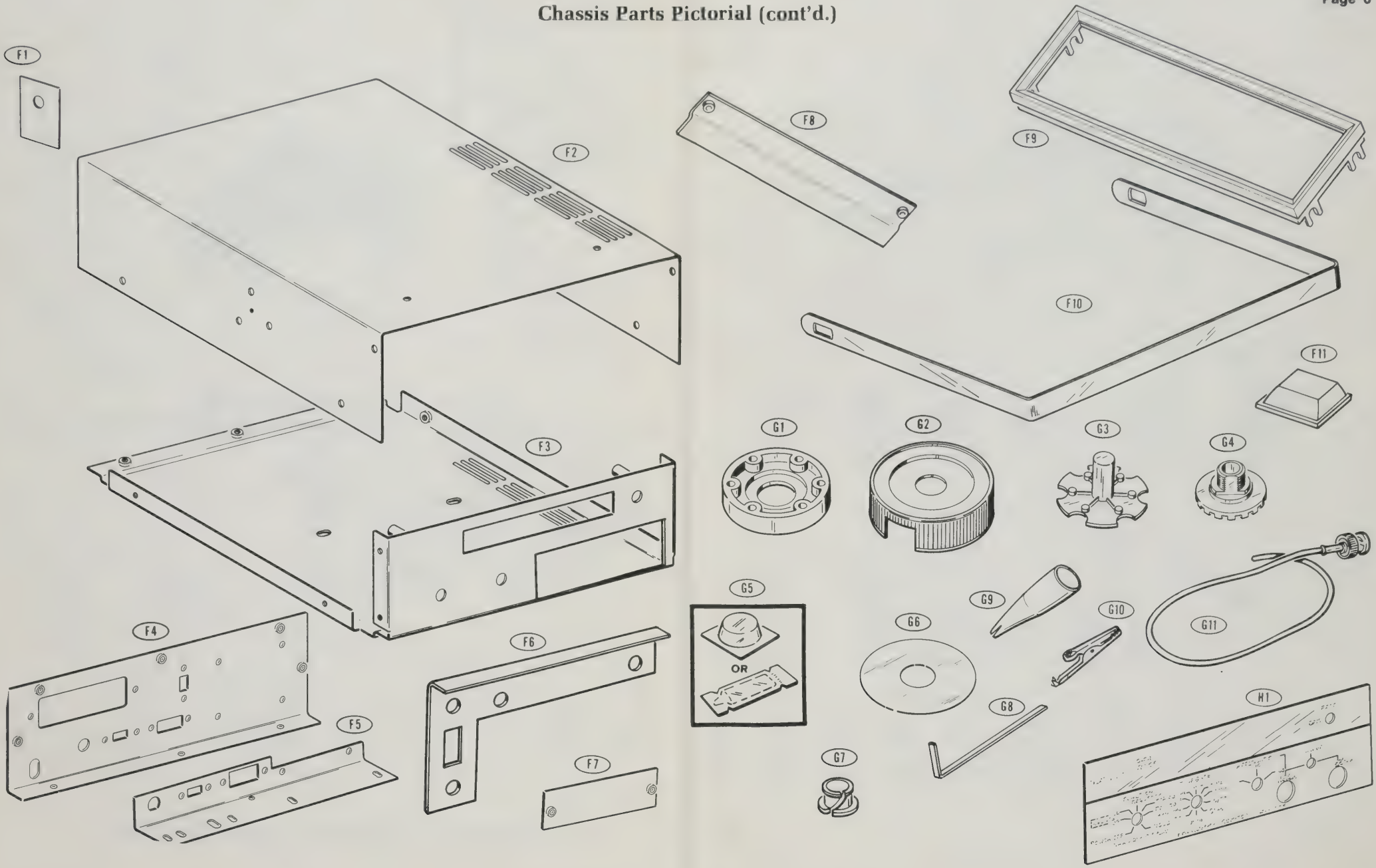


PICTORIAL 4-2

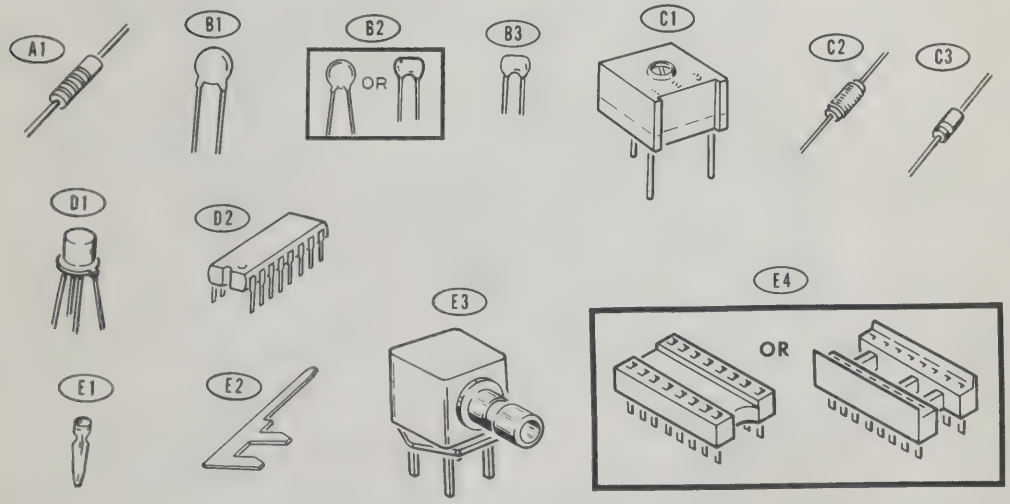


PICTORIAL 4-3

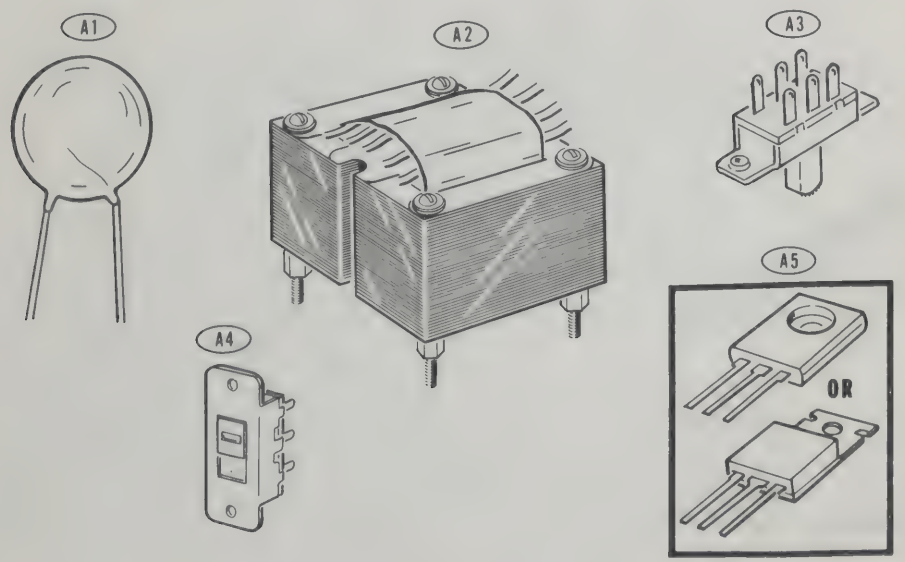
Chassis Parts Pictorial (cont'd.)

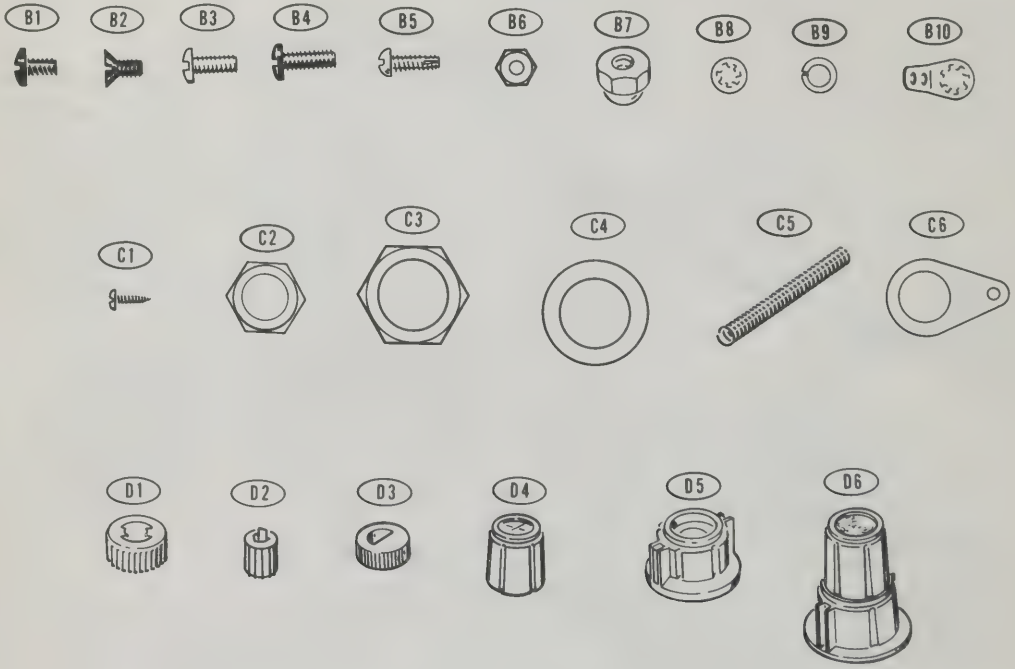


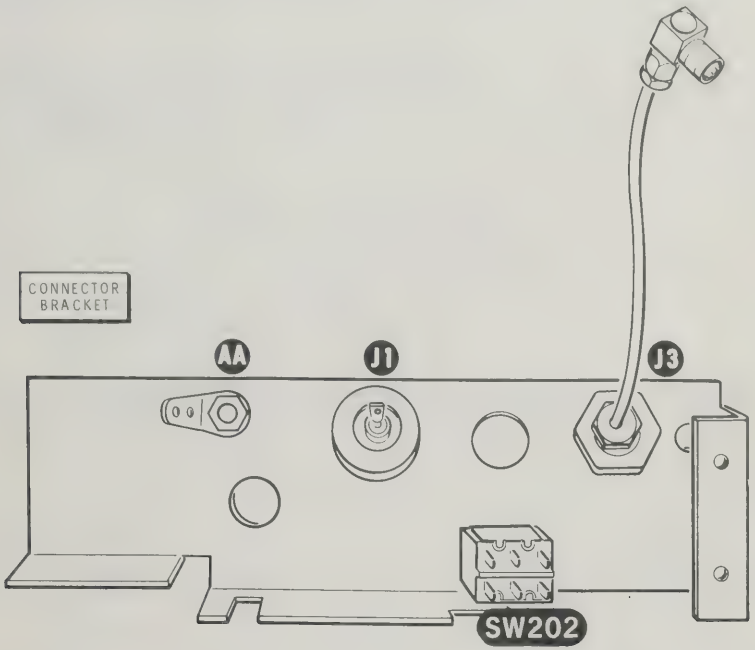
INPUT CIRCUIT BOARD PARTS PICTORIAL



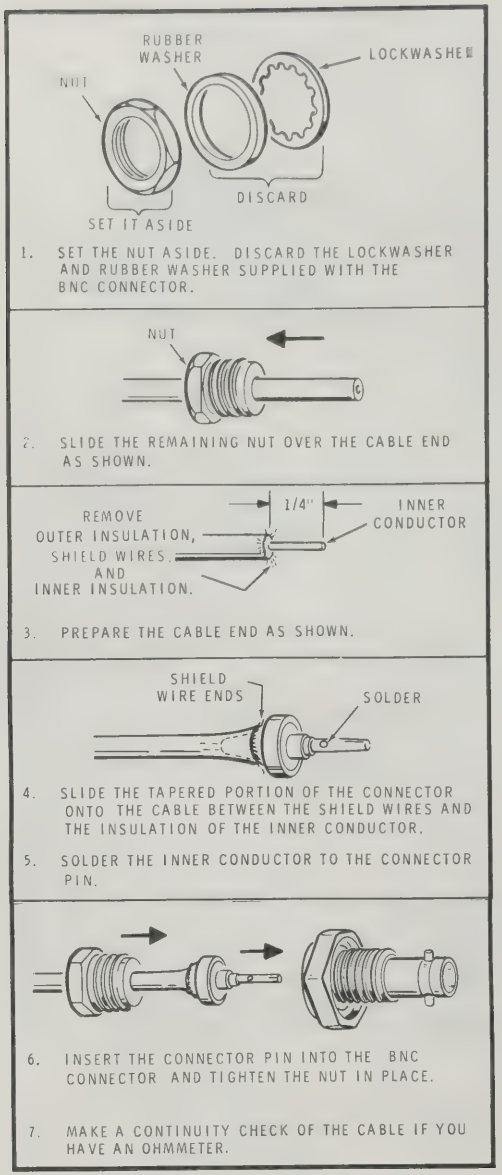
CHASSIS PARTS PICTORIAL





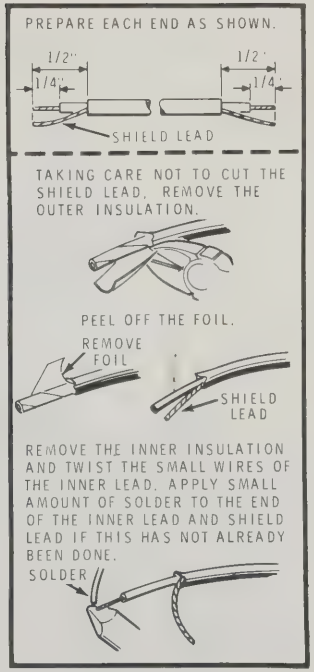


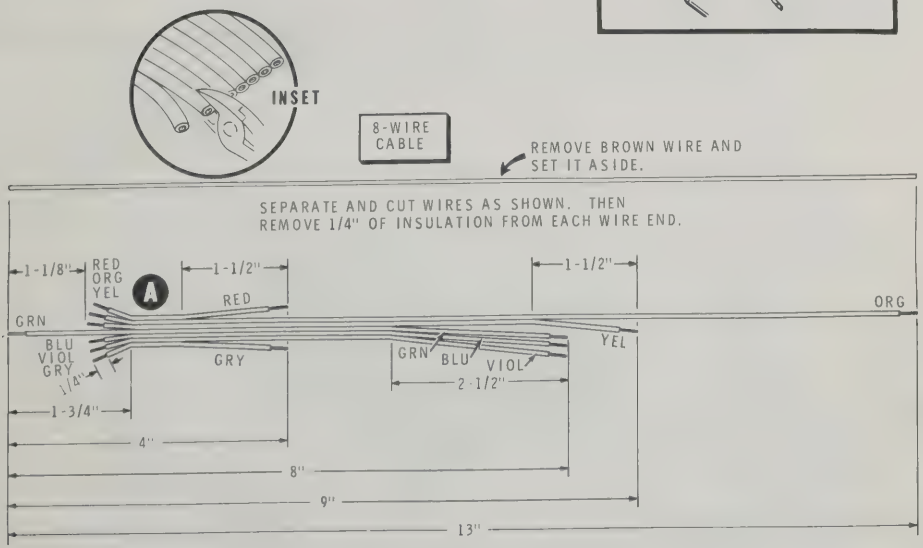
PICTORIAL 2-7


RUBBER WASHER
LOCKWASHER
NUT
DISCARD
SET IT ASIDE
1. SET THE NUT ASIDE. DISCARD THE LOCKWASHER AND RUBBER WASHER SUPPLIED WITH THE BNC CONNECTOR.
NUT
2. SLIDE THE REMAINING NUT OVER THE CABLE END AS SHOWN.
1/4"
INNER CONDUCTOR
REMOVE OUTER INSULATION, SHIELD WIRES, AND INNER INSULATION.
3. PREPARE THE CABLE END AS SHOWN.
SHIELD WIRE ENDS
SOLDER
4. SLIDE THE TAPERED PORTION OF THE CONNECTOR ONTO THE CABLE BETWEEN THE SHIELD WIRES AND THE INSULATION OF THE INNER CONDUCTOR.
5. SOLDER THE INNER CONDUCTOR TO THE CONNECTOR PIN.
6. INSERT THE CONNECTOR PIN INTO THE BNC CONNECTOR AND TIGHTEN THE NUT IN PLACE.
7. MAKE A CONTINUITY CHECK OF THE CABLE IF YOU HAVE AN OHMMETER.

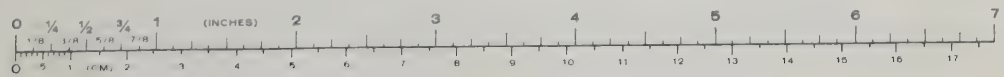
Detail 2-7E

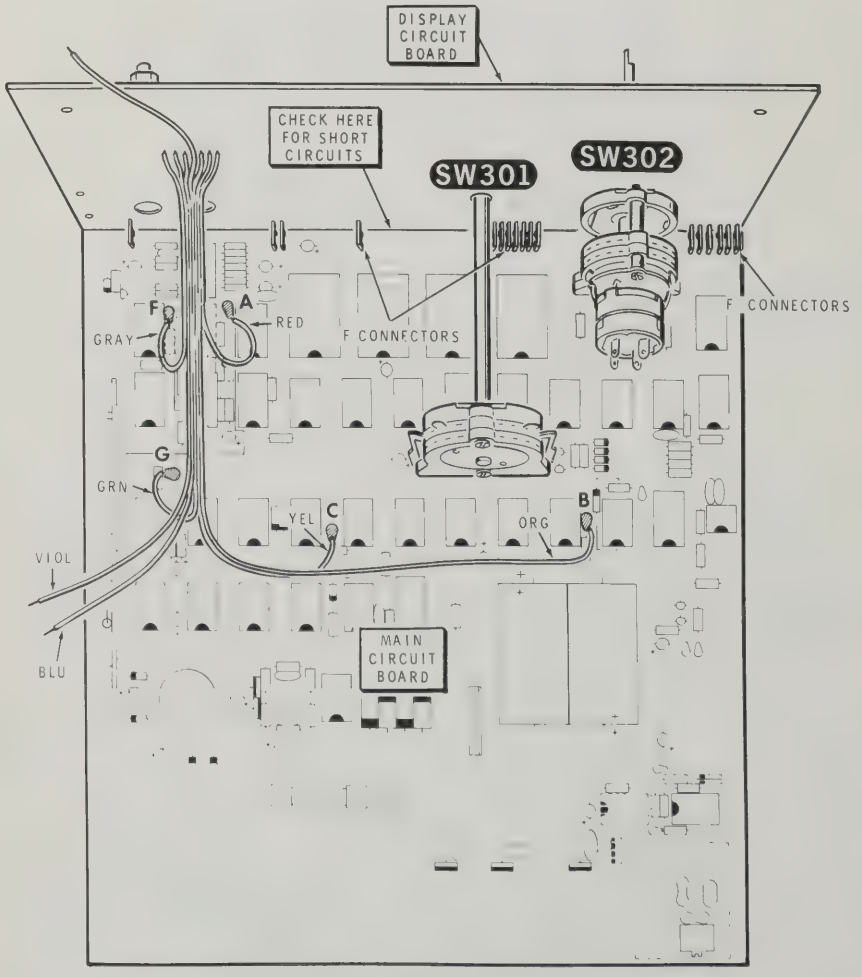
Detail 1-15A


PREPARE EACH END AS SHOWN.
1/2"
1/4"
SHIELD LEAD
TAKING CARE NOT TO CUT THE SHIELD LEAD, REMOVE THE OUTER INSULATION.
PEEL OFF THE FOIL.
REMOVE FOIL
SHIELD LEAD
REMOVE THE INNER INSULATION AND TWIST THE SMALL WIRES OF THE INNER LEAD. APPLY SMALL AMOUNT OF SOLDER TO THE END OF THE INNER LEAD AND SHIELD LEAD IF THIS HAS NOT ALREADY BEEN DONE.
SOLDER

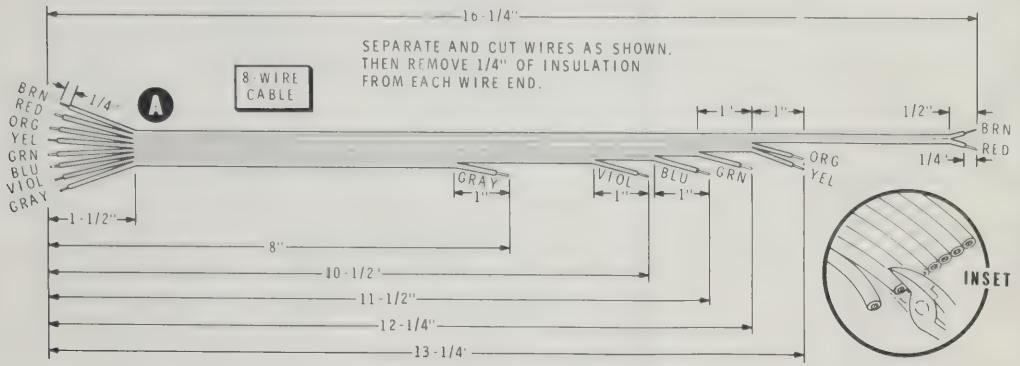


Detail 2-5A



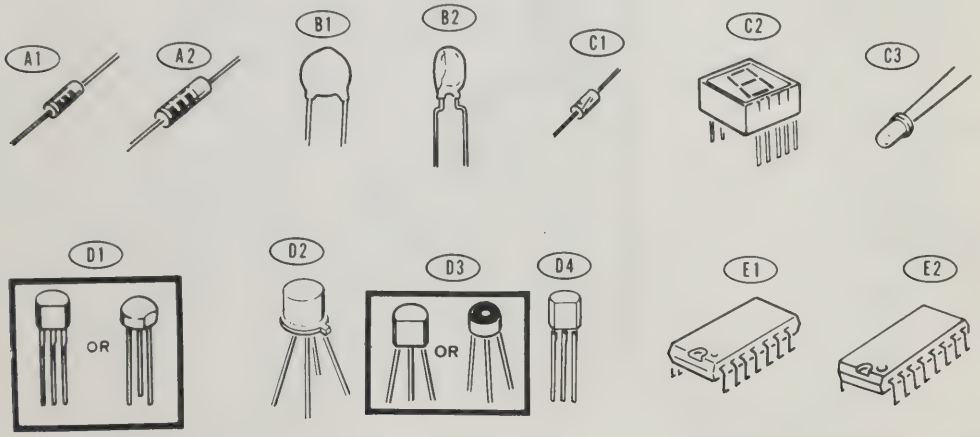


PICTORIAL 2-6



Detail 1-14A

DISPLAY CIRCUIT BOARD PARTS PICTORIAL



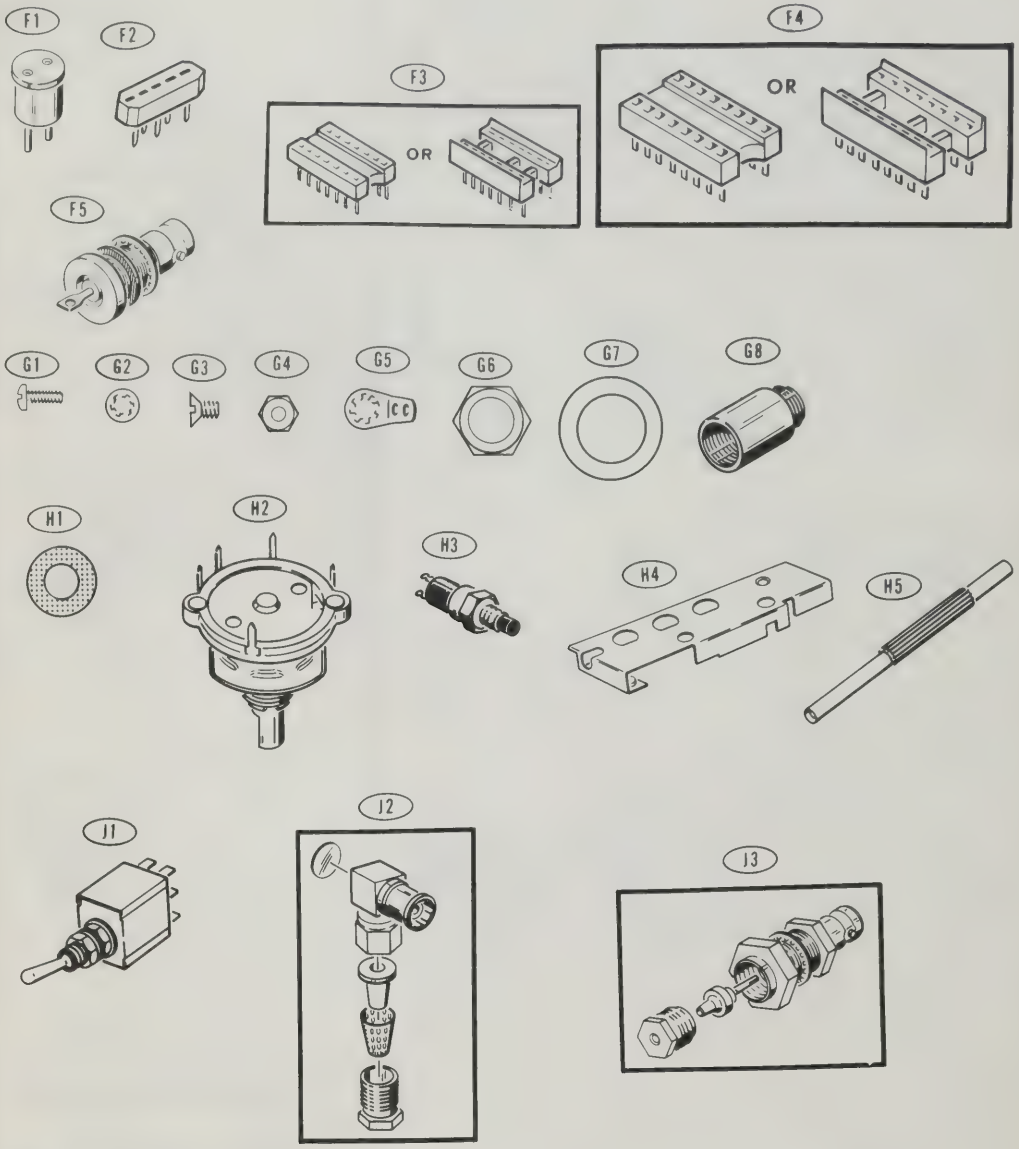
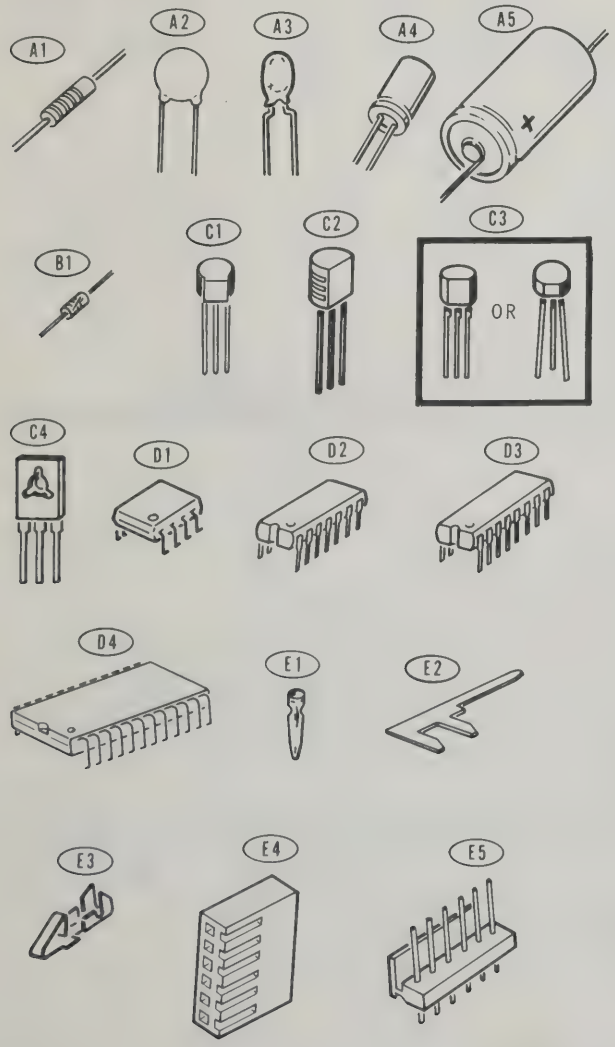
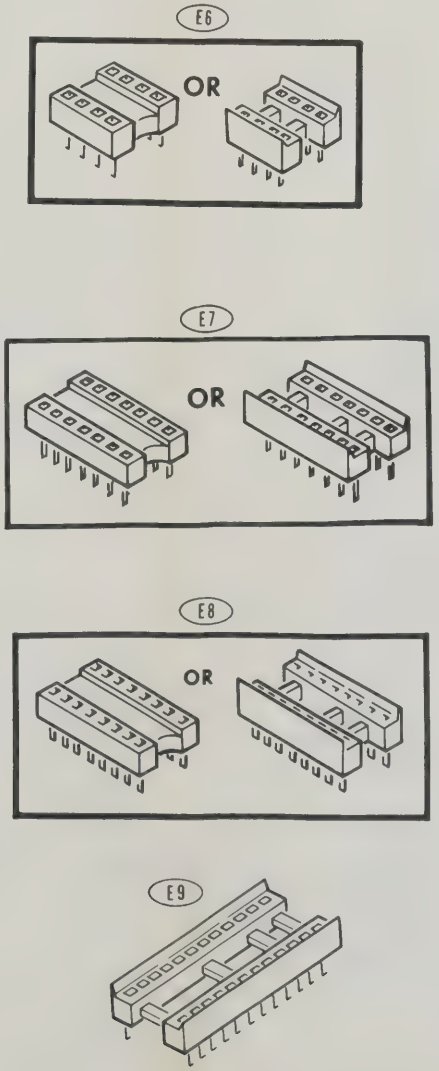


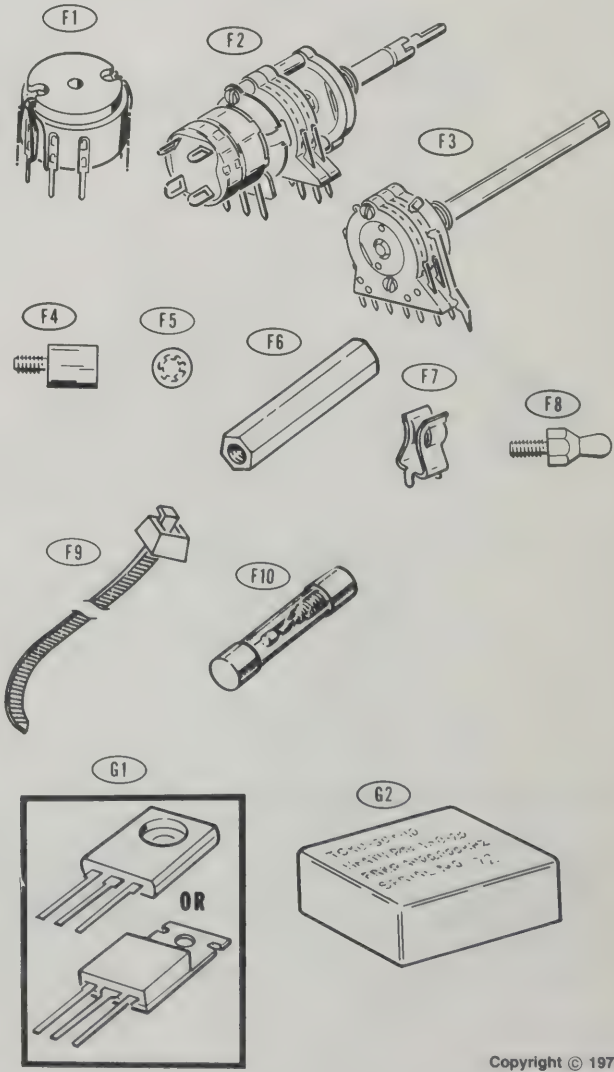
ILLUSTRATION BOOKLET

Part of 595-1917-01

MAIN CIRCUIT BOARD PARTS PICTORIAL

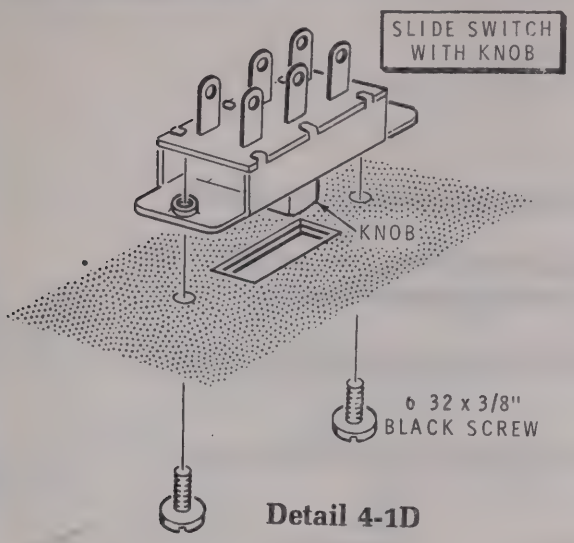






Copyright © 1977
Heath Company
All Rights Reserved
Printed in the United States of America

Model IM-4120

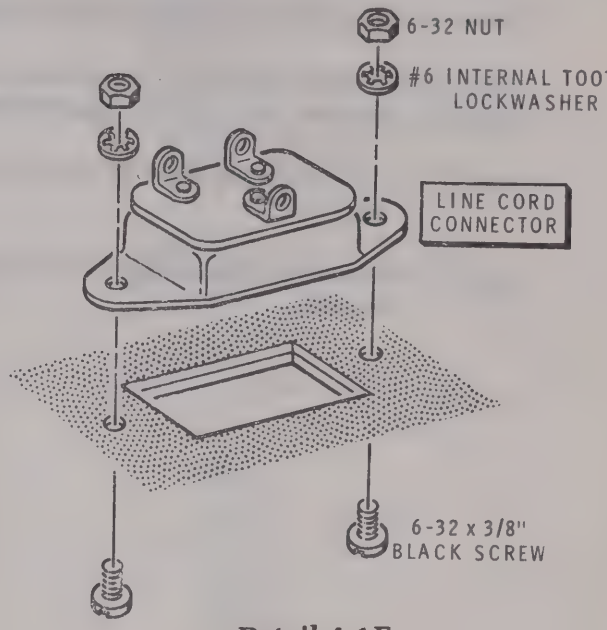


Detail 4-1D

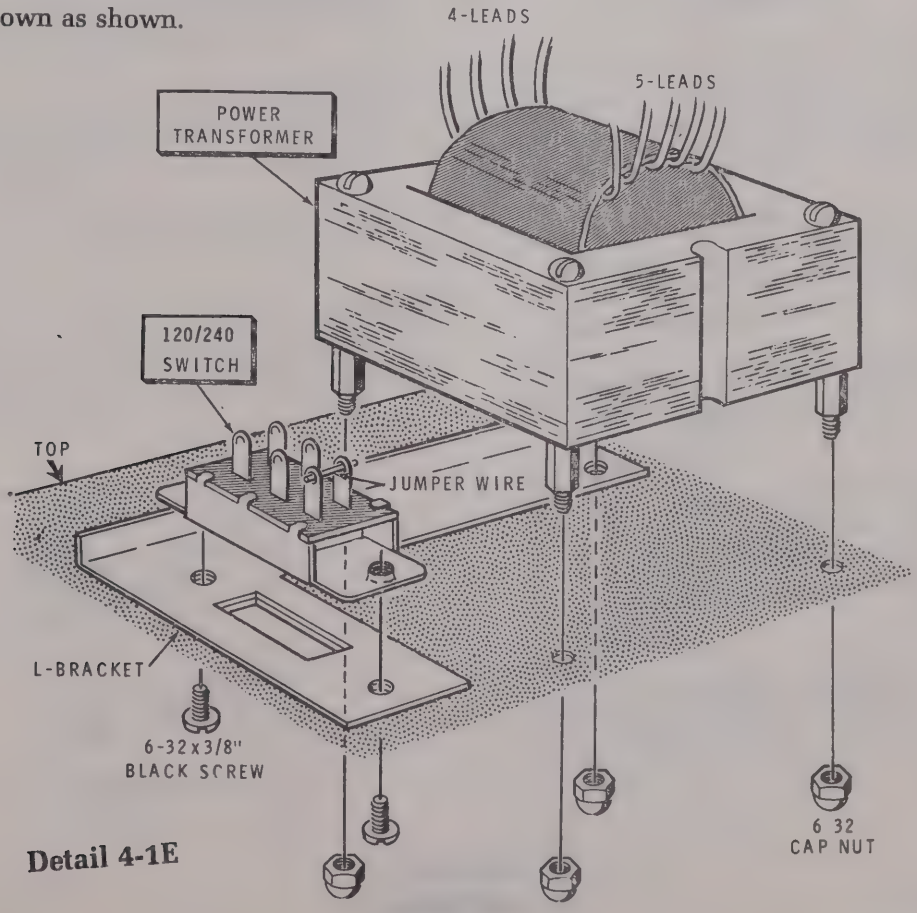
( ) T1: Refer to Detail 4-1E and mount the power transformer through the L-bracket holes and the back panel at T1. Use four 6-32 cap nuts. Be sure the leads come out of the transformer as shown in Pictorial 4-1.

( ) J6: Refer to Detail 4-1F and mount the line cord connector at J6. Use two 6-32 × 3/8" black screws, two #6 internal tooth lockwashers, and two 6-32 nuts as shown. Be sure the center is positioned down as shown.

( ) Tighten the mounting hardware of the previous four parts you installed. Be sure the solder lug of connector J4 is bent up and positioned as shown in the Pictorial and switch SW3 operates freely.



Detail 4-1F



Detail 4-1E

HEATH
Schlumberger

HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022

IMPORTANT NOTICE

Please make the following changes in your Manual before you start to assemble your kit.

You may have received an extra 100 pF ceramic capacitor (#21-75) in your kit. If this has happened, you may discard this capacitor after you have completed your kit.

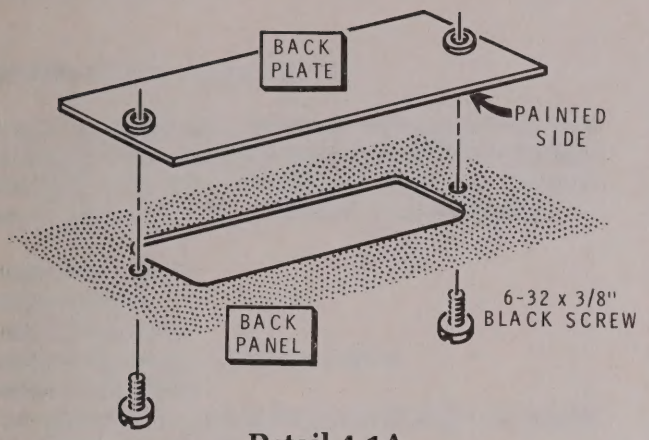
Page 50 — Tape the new Page 50 (supplied with this Notice) over Page 50 in your Manual.

Page 51 — Turn this Notice over and then tape the new Page 51 over Page 51 in your Manual.

Thank you,

HEATH COMPANY

STEP-BY-STEP ASSEMBLY



Detail 4-1A

Refer to Pictorial 4-1 (Illustration Booklet, Page 7) for the following steps.

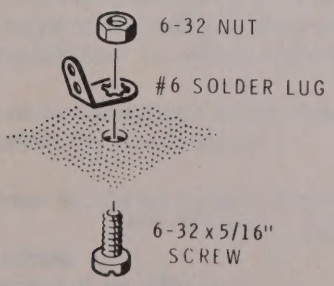
( ) Place a soft cloth on your work surface to protect the back panel in the following steps.

( ) Place the back panel (printed side down) on your work surface as shown in the Pictorial.

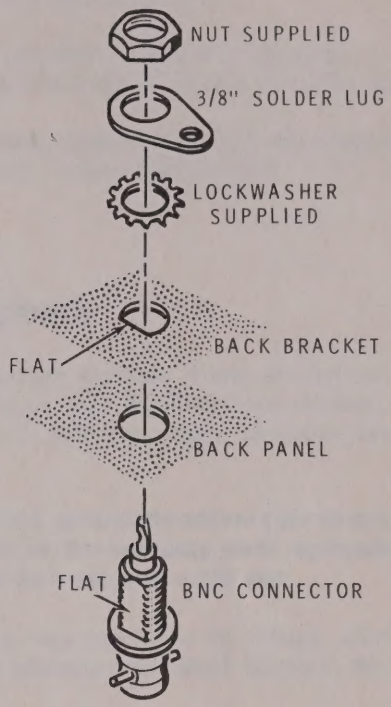
( ) Refer to Detail 4-1A and mount the back plate to the back panel at BA. Be sure the painted side is as shown. Use two 6-32 × 3/8" black screws.

( ) Position the back bracket as shown in the Pictorial.

( ) Refer to Detail 4-1B and mount a #6 solder lug to the back bracket at BC. Use a 6-32 × 5/16" screw and a 6-32 nut. Position the solder lug as shown.



Detail 4-1B



Detail 4-1C

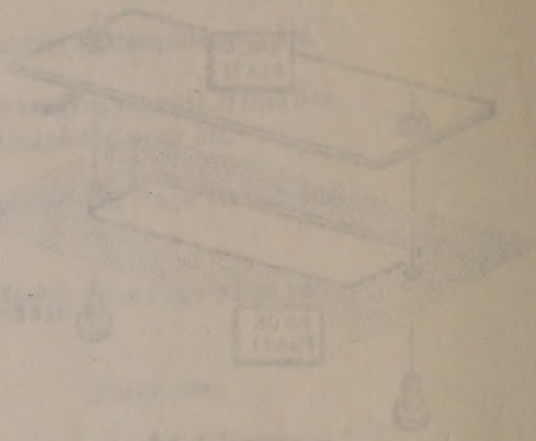
NOTE: In the following steps, you will mount the back bracket to the back panel. Therefore, only loosely mount the next four parts. Then tighten all the hardware when you are instructed to do so.

( ) J4: Refer to Detail 4-1C and mount the BNC connector at J4 (through the back panel and back bracket). Use the hardware supplied with the connector and the 3/8" solder lug as shown.

( ) SW3: Refer to Detail 4-1D and mount the slide switch with knob at SW3 with two 6-32 × 3/8" black screws.

( ) SW1: Refer to Detail 4-1E and mount the L-bracket and the 120/240 switch at SW1. Use two 6-32 × 3/8" black screws. Be sure the switch lugs with the jumper wire are positioned as shown.

( ) On the outside of the back panel, position SW1 to either "120" or "240" — whichever position matches the fuse you installed earlier.



CUSTOMER SERVICE

REPLACEMENT PARTS

Please provide complete information when you request replacements from either the factory or Heath Electronic Centers. Be certain to include the **HEATH** part number exactly as it appears in the parts list.

ORDERING FROM THE FACTORY

Print all of the information requested on the parts order form furnished with this product and mail it to Heath. For telephone orders (parts only) dial 616 982-3571. If you are unable to locate an order form, write us a letter or card including:

- Heath part number.
- Model number.
- Date of purchase.
- Location purchased or invoice number.
- Nature of the defect.
- Your payment or authorization for COD shipment of parts not covered by warranty.

Mail letters to: Heath Company
Benton Harbor
MI 49022
Attn: Parts Replacement

Retain original parts until you receive replacements. Parts that should be returned to the factory will be listed on your packing slip.

OBTAINING REPLACEMENTS FROM HEATH ELECTRONIC CENTERS

For your convenience, "over the counter" replacement parts are available from the Heath Electronic Centers listed in your catalog. Be sure to bring in the original part and purchase invoice when you request a warranty replacement from a Heath Electronic Center.

TECHNICAL CONSULTATION

Need help with your kit? — Self-Service? — Construction? — Operation? — Call or write for assistance. you'll find our Technical Consultants eager to help with just about any technical problem except "customizing" for unique applications.

The effectiveness of our consultation service depends on the information you furnish. Be sure to tell us:

- The Model number and Series number from the blue and white label. IM-4120 02813
- The date of purchase.
- An exact description of the difficulty.
- Everything you have done in attempting to correct the problem.

Also include switch positions, connections to other units, operating procedures, voltage readings, and any other information you think might be helpful.

Please do not send parts for testing, unless this is specifically requested by our Consultants.

Hints: Telephone traffic is lightest at midweek — please be sure your Manual and notes are on hand when you call.

Heathkit Electronic Center facilities are also available for telephone or "walk-in" personal assistance.

REPAIR SERVICE

Service facilities are available, if they are needed, to repair your completed kit. (Kits that have been modified, soldered with paste flux or acid core solder, cannot be accepted for repair.)

If it is convenient, personally deliver your kit to a Heathkit Electronic Center. For warranty parts replacement, supply a copy of the invoice or sales slip.

If you prefer to ship your kit to the factory, attach a letter containing the following information directly to the unit:

- Your name and address.
- Date of purchase and invoice number.
- Copies of all correspondence relevant to the service of the kit.
- A brief description of the difficulty.
- Authorization to return your kit COD for the service and shipping charges. (This will reduce the possibility of delay.)

Check the equipment to see that all screws and parts are secured. (Do not include any wooden cabinets or color television picture tubes, as these are easily damaged in shipment. Do not include the kit Manual.) Place the equipment in a strong carton with at least THREE INCHES of *resilient* packing material (shredded paper, excelsior, etc.) on all sides. Use additional packing material where there are protrusions (control sticks, large knobs, etc.). If the unit weighs over 15 lbs., place this carton in another one with 3/4" of packing material between the two.

Seal the carton with reinforced gummed tape, tie it with a strong cord, and mark it "Fragile" on at least two sides. Remember, the carrier will not accept liability for shipping damage if the unit is insufficiently packed. Ship by prepaid express, United Parcel Service, or insured Parcel Post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

HEATH

Schlumberger

HEATH COMPANY • BENTON HARBOR, MICHIGAN

THE WORLD'S FINEST ELECTRONIC EQUIPMENT IN KIT FORM

LITHO IN U.S.A.